SCIENCE

VOL. 102 FRIDAY, DECEMBER 7, 1945 No. 2658

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SCIENCE: A Weekly Journal, since 1900 the official organ of the American Association for the Advancement of Science. Published by the American Association for the Advancement of Science every Friday at Lancaster, Pennsylvania.

Editors: JOSEPHINE OWEN CATTELL and JAQUES CATTELL.

Policy Committee: MALCOLM H. SOULE, ROGER ADAMS and WALTER R. MILES.

Advertising Manager: THEO. J. CHRISTENSEN.

Communications relative to articles offered for publication should be addressed to Editors of Science, The Science Press, Lancaster, Pa.

Communications relative to advertising should be addressed to THEO. CHRISTENSEN, Advertising Manager, American University, 3801 Nebraska Ave., NW, Washington 16, D. C.

Communications relative to membership in the Association and to all matters of business of the Association should be addressed to the Permanent Secretary, A.A.A.S., Smithsonian Institution Building, Washington 25, D. C.

Annual subscription, $6.00 Single copies, 15 cents

THE BASIC MECHANISMS OF STATIC ELECTRIFICATION

By Professor LEONARD B. LOEB

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THE term "static electrification," as here used, covers all processes for producing segregation of positive and negative electrical charges by mechanical actions which operate by contact or impact between solid surfaces, between solid and liquid surfaces, or in the rupture of solid or liquid surfaces by gases. These involve such phenomena as frictional electrification, spray electrification, electrification in dust storms, etc. A review of these phenomena in general shows a most unsatisfactory array of discordant, often non-reproducible and confusing results, whose theoretical interpretation in some cases is quite hopeless.[1,2,3,4,5]

It is believed that in a considerable measure this situation results from the fact that many investigators are not alert to the possibility that in any one aspect of their studies not one but perhaps two or more of the various basic mechanisms may have been active. Such complications make theoretical interpretation in terms of any single proposed mechanism most difficult. In order to clarify the situation it is proposed to list the known mechanisms and briefly to discuss them. The basic mechanisms active are:

(1) Electrolytic effects, caused by distribution of electrolytic ions in solutions of liquids of high dielectric constants between the solutions and metals or solids, on contact, followed by mechanical separation. Since diffusion of ions across interfaces build up considerable potentials,

[1] H. F. Richards, *Phys. Rev.*, 22: 122, 1923; and 16: 290, 1920.

[2] Cardani, *N. Cimento*, 23: 199, 1922; Jones, *Phil. Mag.*, 29: 272, 1915; Owen, *Phil. Mag.*, 17: 457, 1909; E. Perucca, *N. Cimento*, 22: 56, 1921.

[3] Coehn, *Ann. de Phys.*, 30: 777, 1909, and 43: 1048, 1914.

[4] Ulrey, *Phys. Rev.*, 12: 47, 1918.

[5] P. E. Shaw and C. S. Jex, *Proc. Roy. Soc. London*, A118: 97, 1928; A. Fleming, *Proc. Roy. Soc. London*, 53: 51, 1941; R. Schuurman, *Proc. Phys. Soc. London*, 53: 547, 1941; F. Boning, *Zeits. f. Tech. Physik*, 8: 385, 1927; H. Israel, *Zeits. f. Tech. Physik*, 9: 289, 1928.

heavy electrification may occur. These effects are well known but may appear in unusual connections.

(2) Contact or Volta electrification between clean, dry metallic surfaces or surfaces of metallic conductors and of semi-conductors. These phenomena are well known in the theory of the metallic state and involve movements of *free electrons* across metallic potential barriers as a result of differences in the work function of the metal surfaces.

(3) Spray electrification, produced by the disruption of surface films of liquids and solutions by mechanical forces such as the atomizing and bubbling of liquids and perhaps the shattering of liquid jets of high velocity by solid surfaces.

(4) Frictional or tribo electrification, as a result of impacts or contact and subsequent separation between *dry* non-metallic solid surfaces. This phenomenon is connected with the theory of the solid state and probably depends on transfer of *ions, not electrons,* between lattices of solids. It may involve polarization by pressure and mechanical rupture of polarized units by mechanical forces.[1]

(5) Effects by which ions and electrons, created by electrical phenomena in gases or in flames, are segregated and separated by mechanical forces, with or without the presence of electrical fields, produced by mass motions of gases or solids. Examples of these phenomena in processes such as the electrical segregations in flames in exhaust gases from flues, and in the Van de Graaf static generator are well known.

(1) *The Electrolytic Mechanisms.* One of the original theories of contact electrification between solids assumed that *all* such action was electrolytic in nature and involved thin aqueous films on surfaces. However, studies of phenomena with really dry surfaces indicated that contact electrification was more complex and that mechanisms (2) and (4) both produced static electrification which were ***not electrolytic.*** That any liquid of high dielectric constant will engage in exchange of ions in contact with metals and solid surfaces is, however, well known, and where contact electrification involves the possibility of such exchanges the phenomenon must be analyzed, considering such possibility. It is necessary, therefore, to consider the role of mechanism (1) in all phenomena involving contact between such liquids and surfaces, flow of such liquids over surfaces[3] and in impact of liquids against surfaces resulting in electrified sprays.[6] Consideration of such actions indicates the need of much more work. It may clarify some of the following obscure phenomena. The writer in some unpublished work observed electrification of an insulated section of copper tube when kerosene, an inert hydrocarbon mixture, was allowed to flow through it. It was found that when this kerosene was clean and *dry* there was no charging. Again S. Chapman[7] studied the charges of droplets of atomized liquids by means of the Millikan oil drop method. He observed that drops with radii of 10^{-5} to 10^{-4} cm in atomized dielectric liquids were highly charged, in some cases with as many as 600 electrons. Droplets of both signs of charge increased roughly in a linear fashion with drop radius and increased further with dielectric constant of the liquid. These charges were supposed to result from spray electrification, mechanism (3). Later careful review of the data on spray electrification indicated that such a mechanism could not be expected to lead to droplets with more than a few electrons of charge.[8] Hence some other mechanisms must have been active. Electrolytic action is a possible factor, although how it leads to both signs of charge is a problem, unless the sprayed liquids came in contact with two different surfaces. It is clear, however, that highly charged particles of this magnitude could be achieved in such actions, since ion concentrations in solution and segregations at surfaces are very high. Again Lenard[6,9] in his work on spray electrification reported that by far the greatest charge separation with its spray having of the order of 90 per cent. negative carriers came from the shattering of liquid jets by metals. This, together with reputed observations on the charging of airplane structures under impact of water drops, where very heavy charges were observed which changed in magnitude and sign with the surface coating, again points to other phenomena than mechanism (3). Similarly the dangerous static charges in handling of gasoline by pouring between metal containers and filtering it through chamois skin and metals should be studied with mechanism (1) in mind. It is suspected that an electrolytic mechanism, (1), may be playing an important role in electrification in Lenard's and in the airplane observations where drops are shattered by impact against solids.

(2) *The Contact Potential Mechanism.* The contact potential phenomenon has been quite completely investigated, both theoretically and experimentally, on clean, outgassed metal surfaces. In general, the metal with the higher work function W_A will become positive to that with lower work function W_B, so that on separation $V_{AB} = W_A - W_B$. *Electrons* have migrated from metal A to metal B in this process. This phenomenon is thus *electronic* and clearly defined. It presents no difficulties except for the effect of impurities and absorbed gas films on the surfaces, which change the work function. Since even at 10^{-8} mm pressure monomolecular gas films can form in a few minutes, and since gas films may be of different sorts in the same gas, in different pressure regions,

[6] P. Lenard, *Wied. Ann.*, 46: 584, 1892, and *Ann. der Phys.*, 47: 413, 1915; Busse, *Ann. der Phys.*, 76: 493, 1925.

[7] S. Chapman, *Physics*, 5: 150, 1934.

[8] S. Chapman, *Phys. Rev.*, 52: 184, 1937, *and Phys. Rev.*, 54: 520 and 528, 1938.

[9] Bühl, *Kolloid Zeits.*, 59: 436, 1932.

as Langmuir[10] has shown, reproducible results require that great care be used. The electrical exchanges in contacts between semi-conductors, such as CuO, and metal, are more complicated owing to the complicated electronic level structures in such substances. However, in all cases it is the *electron* which moves across the boundary and causes charging. The effect observed with semi-conductors may be modified by temperature, illumination by light, impurities, etc. In view of the familiarity of these phenomena there has been a tendency to ascribe all solid to solid electrification to electron transfer.[1] This in the past has confused the picture. Recent work by Debeau[11] has shown that the phenomena in the case of all but materials possessing free or quasi free electrons is more likely an ionic exchange—even if a metal is one of the solids.

(3) *The Spray Electrification Mechanism.* Spray electrification, or "Wasserfall Electrizität," as P. Lenard,[6, 9] its earliest investigator, termed it, is a phenomenon which depends on the action of surface forces in dielectric liquids in increasing the concentration of electrons or perhaps of negative ions in the outer surface layers. It appears as if perhaps in 10^4 or 10^5 molecules in the surface of pure water there is one extra electronic charge.[3, 6, 8] Thus an electrical double layer exists in these liquids, with the outside negative and the inside positive, which in water is about 2×10^{-6} cm thick. The physical basis for such layers has not been formulated as yet. If the liquid surface is disrupted by atomizing or bubbling, then the finer droplets emerge with a preponderance of negative charges. Larger drops are neutral, or positive and negative in equal amounts. Subsequent evaporation or condensation may alter the size of such charged droplets. S. Chapman has observed several groups of ions of both signs, of different mobilities of a wide range of values in the bubbling and spraying of water, and has tentatively suggested the nature of the various ion groups.[8] Dissolved salts and other substances alter the effect in pure water, generally reducing the magnitude of the charges and the proportion of faster ions and equalizing the number of slower positive and negative ions.[6, 8, 9] Electrolytic ions enter the double layer and alter it. Alcohol and other liquids show similar effects but with less differences in the number of positive and negative ions.[8] Pure hydrocarbons show little charging, but large positive and negative carriers of small charge are observed,[7, 8] in equal numbers. The charges of the faster ions appear to be of the order of a few electrons. For spray from impact of water jets on metals, Bühl[11] quotes Lenard as reporting that of the order of 90 per cent. of the spray carriers were negative. With bubbling, both Lenard and Chapman find that 75 per cent. of the carriers are negative, while with atomized water the negative ions are present to an extent of about 55 per cent.[8, 9] In metallic liquids Bühl reports that with pure clean Hg its spray is positive.[9] The sign of the charge is altered by traces of oxide dust. Traces of Zn in the Hg may reverse the sign of charging. From the results quoted it is clear that spray electrification is a definite mechanism in its own right, but that it may be complicated where spraying occurs by electrolytic and other factors. In metals it is complicated by gas layers, oxidation and other effects and requires more study. It is probably one of the most important mechanisms of the electrical separation in thunder showers and may be of some importance in the charging of planes in flight. Both of the above cited phenomena may be affected by other mechanisms, *i.e.,* the thunder storm by the theory proposed by C. T. R. Wilson,[12] which belongs under mechanism (5) and the plane charging by mechanism (1). At present the heavily charged large drops observed by Chapman[7] with an atomizer can not be reconciled with mechanism (3), where segregations of *many charges of one sign* in small volumes of surfaces are unlikely.

(4) *Frictional or Tribo Electrical Mechanisms.* The most obscure of all static charging phenomena to date are the static charging of dry non-metallic particles by contact between themselves or with metals either on impact or just on contact,[5] *i.e.,* frictional charging. The control of studies of these phenomena has been most difficult. Leaving aside the possible complications by mechanisms (1), with liquid films, the effect is real and very important.[1] Some progress was made in a recent study of Debeau[11] on the electrification of SiO_2 and NaCl in contact with Ni where dry and relatively controllable surfaces could be obtained by baking out with some control of the gas content. It was found that reproducible results could be obtained and that gas films absorbed on the surfaces radically altered the charges observed. These changed with the gas pressure and nature of the gas. Thus H_2 and H_2O on Ni led to very confusing results while dry N_2, air and O_2 gave consistent results. Films on one, or both, metal and solid having two entirely different absorption isotherms[10] were active. The loss of the one film, perhaps the outer film, leading to inactive surfaces while the loss of the second, perhaps inner film, again increased the electrification. The charge on SiO_2 was negative, but on rock salt it was positive. The conclusion reached was that

[10] I. Langmuir, *Jour. Am. Chem. Soc.*, 38: 2267, 1916, and 40: 1351, 1918.

[11] D. Debeau, *Phys. Rev.*, 66: 9, 1944.

[12] C. T. R. Wilson, *Proc. Phys. Soc. London*, 37: 320, 1929, and *Jour. Franklin Inst.*, 208: 1, 1929.

these effects are closely related with the theory of the solid state, which is yet in its infancy. The charging was believed to be a result of the exchange of *atomic* or *molecular ions* to fill up holes, or to remove excess ions, resulting from holes in the lattices from its surface. Surface films of gases on metals are in some cases in the ionic state, which complicates the picture.

Charging by friction of such complex organic substances as cats' fur, ebonite, sealing wax and glass has its obvious explanation in the possible rupture of long chain polar molecules such as those of fatty acids, etc., which through linkage of polar groups at one end with the contacting surface result in the rupture of the molecules and electrical separations. Again the rupture of strained piezo-electric crystals, or rupture by mechanical means, during pressure induced polarization of other substances could lead to electrification.[1] This whole set of phenomena requires much more work, with care to eliminate the actions of other well-known mechanisms, before it is understood.

(5) The action of the rapid diffusion of electronic carriers causing local separations in space in gases, which can be increased by mechanical means, is too well known to require discussion. There are many examples of such phenomena which do not require discussion here since they do not often confuse results of other static separation studies.

However, it should be considered that where electrical fields by polarization cause segregations of charges in droplets or solids in which mechanical rupture along an axis normal to the field can separate the polarized charge segregations, can not be ignored in all these investigations. Thus it could be possible that Chapman's[7] heavy charges on drops produced by atomization of various polarizable liquids may have been caused by the presence of unsuspected fields in the neighborhood of his atomizer. Such an effect of charge segregation with mechanical effects of falling drops in the presence of ions in the air has been invoked by C. T. R. Wilson[12] to explain thunderstorm electrification. The mechanism proposed certainly gives charged droplets. Whether it accounts for most of the electrification in thunder clouds is yet another question. A paper by J. Frenkel[13] which indicates a third mechanism in the electrification of clouds by mechanical forces has just been received by the writer. In this preferential condensation on negatively charged water nuclei of minute size causes charge segregation by gravitational forces. Its highly suggestive character merits study even if it does not apply to the turbulent regime of thunderstorm generation.

In any case, enough has been said to indicate the need for caution and discrimination in the study of static phenomena as influenced by these causes. It is clear that static electrification is caused by at least five different basic mechanisms, or perhaps six, if we include breaking of pressure or field polarized groups. The realization of this and the considerations of the influence of any of these mechanisms on observed phenomena it is hoped will alert investigators to the possibilities involved and assist in clarifying future and past studies.

THE BIOCHEMISTRY OF MUSCLE TRAINING[1]

By Professor ALEXANDER V. PALLADIN

MEMBER OF THE ACADEMY OF SCIENCES OF U.S.S.R.; PROFESSOR OF BIOCHEMISTRY, UNIVERSITY OF KIEV

OUR researches on the biochemistry of muscle training began with our studies of the metabolism and role of creatine in muscle. This work[2] showed that during training the creatine in muscle increased. This observation signified to us the possibility that creatine plays a definite functional role in muscle. An investigation[3] of the creatine content of divers muscle from many fish demonstrated that muscles which were permanently, that is naturally trained, contain more creatine than muscles that work but little; for example, the muscles of the lateral fins of shark, ruff, etc., contain more creatine than the dorsal (spinal) muscles. These findings permitted the conclusion that during artificial and natural training muscle becomes rich in creatine. Further experiments[4,5,6,7,8,9,10,11] showed that muscles in which the work capacity has been increased by training possessed also higher levels of phosphocreatine, carnosine,

[1] Presented at Stanford University, Biology Seminar, May 31, 1945.

[2] A. V. Palladin and D. Z. Ferdman, *Z. physiol. Chem.*, 174: 284, 1928.

[3] A. V. Palladin and I. D. Ochrimenko, *Ukranian Biochem. Jour.*, 12: 1938.

[13] J. Frenkel, *Jour. of Phys., USSR*, 8: 285, 1944.

[4] B. M. Koldaev and R. Gelman, *Ukrainian Biochem. Jour.*, 9: 35, 1936.

[5] B. M. Koldaev, *Ukrainian Biochem. Jour.*, 10: 4, 1937.

[6] M. F. Mereginski, *Ukrainian Biochem. Jour.*, 9: 25, 1936.

[7] A. V. Palladin, *Am. Jour. Physiol.*, 90: 1929.

[8] A. V. Palladin, *Jour. Physiol. U.S.S.R.*, 19: 287, 1935.

[9] A. V. Palladin, *Advances in Biology* (Russian), 7: 3, 1937.

[10] A. V. Palladin, *Ukrainian Biochem. Jour.*, 17: 7, 1941.

[11] D. Z. Ferdman and O. Y. Feinshmidt, *Z. physiol. Chem.*, 183: 261, 1929.

phosphatides, free cholesterol, sodium, calcium and magnesium. On the other hand, it was found[12] that in trained muscle, fatiguing work does not raise the lactic acid content to the extent observed in untrained muscle. This led us to conclude that as a result of training the conditions for oxidation of lactic acid and its resynthesis to glycogen are altered. Following upon these findings, a systematic investigation of the effects of muscle training on the oxidation and synthetic processes within muscle was undertaken.

In all our experiments designed to study the effects of training on muscle metabolism, training was produced in the following manner: The skin over one extremity was shaved and to it an electrode attached to an induction apparatus was applied. The flow of current was interrupted by a metronome. This resulted in rhythmic contraction of the muscles, which were stimulated ten to fifteen minutes twice per day, and continued over a period of fifteen days. As a result of this training the work capacity of the muscles was increased, and simultaneously an increase in the glycogen and creatine content presented a biochemical index of training.

The effects of training and of fatiguing work on oxidation processes of the muscles were studied by estimation of the oxidized and reduced forms of glutathione,[13] of catalase,[14] of the ability to reduce methylene blue,[15] of the oxidation-reduction potential,[16] and of the respiratory activity.[17,18] We found that the concentration of catalase, the reduction capacity for methylene blue (Thunberg method), and the concentration of ascorbic acid[4] were increased in trained muscles. By application of the Warburg technique in the respiration studies, it was found by Sorenyi that training considerably increased the respiration of muscles. The cyanide-resistant portion of respiration increased on the average to a level fifteen times greater than the cyanide-sensitive portion.[19] From these results we concluded that the higher work capacity of the muscle required a higher proportion of the respiratory process not inhibited by cyanide. In fact, cardiac muscle, which has the highest work capacity of all, has a respiratory activity which is least inhibited by cyanide. Under training, the flavine content of the muscle increases[18]; correspondingly the cardiac muscle is conspicuously high in flavine as shown by Sorenyi and Tchepinova. Experiments on various muscles of many animals have shown that the greater the work capacity of muscle, the lower is the proportion of its total respiration which is inhibited by cyanide and the greater is its flavine content.

Training not only increases the respiratory processes of muscle, but also increases aerobic and anaerobic glycolysis.[18] In this connection it is assumed that in trained muscle following the onset of fatigue, the lack of accumulation of lactic acid is not the result of increased carbohydrate resynthesis, but is due rather to the fact that, following training, oxidation and glycolysis are not increased in the same proportion. Attempts to identify the dehydrogenating agents which determine the changes in reduction capacity of muscle showed an increase in succinodehydrogenase and α-glycerophosphate dehydrogenase activity.[20]

Training also improves the conditions for synthetic processes, a fact demonstrated by Koldaev.[21] He found that in a fatigued, preliminarily trained muscle, the capacity of the muscle substance to synthesize phosphate esters is lowered to a much smaller degree than in a muscle similarly fatigued but untrained. Hence we have concluded that training not only raises the work capacity of muscle, but improves the conditions therein which are more favorable for oxidation reduction and synthetic processes.[10] On the other hand, fatiguing work reduces the latter set of conditions.

Alterations in the metabolic processes following fatiguing work are not simply localized in muscle. Under these conditions processes independent of muscle metabolism also undergo change; for example, changes occur in the ability of the organ to oxidize phenol and in the synthesis of its detoxication product. This we established by studying the effect of phenol injected into a rabbit both under resting conditions and under conditions of fatigue.[22]

On the basis of our experiments the following conclusions may be reached: If muscle subjected to preliminary training is worked to the point of fatigue, oxidation processes are disrupted to only a slight degree in comparison with the normal; the decrease induced by fatiguing work in untrained muscle is much greater. Hence a trained muscle does not reach the point of fatigue as rapidly as an untrained muscle and is capable of greater work. The fact that training results in a more favorable milieu for synthetic processes puts a trained muscle on a more favorable basis than an untrained one, in so far as capacity for intensive, prolonged work is concerned.

[12] A. V. Palladin, L. I. Palladina and E. Perzova, *Biochem. Z.*, 236: 268, 1931.
[13] A. V. Palladin, *Ukrainian Biochem. Jour.*, 7: 1, 1933.
[14] A. V. Palladin and e. Rashba, *Jour. Physiol. U.S.S.R.*, 21: 507, 1936.
[15] A. V. Palladin and A. Kashpur, *Jour. Physiol. U.S.S.R.*, 7: 4, 1935.
[16] R. Tchagovetz, *Ukrainian Biochem. Jour.*, 9: 1936.
[17] E. T. Sorenyi, *Ukrainian Biochem. Jour.*, 9: 2, 1936.
[18] E. T. Sorenyi and O. P. Tchepinova, *Ukrainian Biochem. Jour.*, 9: 3, 4, 1936; 10: 4, 1937.
[19] *Idem, Ukrainian Biochem. Jour.*, 11: 3, 1938.
[20] O. P. Tchepinova, *Ukrainian Biochem. Jour.*, 14: 2, 1939; 32: 1940.
[21] B. M. Koldaev, *Ukrainian Biochem. Jour.*, 7: 4, 1935.
[22] A. V. Palladin and L. I. Palladina, *Ukrainian Biochem. Jour.*, 7: 1, 1934.

It was of interest to determine whether the biochemical changes produced by training and fatigue were dependent only upon the degree of training and extent of work or whether other factors were of significance. Previous experiments had suggested the importance of nutritional factors. Experiments were therefore undertaken to elucidate the influence of diet on the metabolic changes produced by training. We started by studying the effects of a vitamin C-free diet. Experiments carried out at the Institute of Biochemistry showed[9] that fatiguing work raised the lactic acid content of the muscle of normal guinea pigs by an average of 28 per cent., and that of scorbutic guinea pigs on a vitamin C-free diet by 48 per cent. That is, work of similar intensity resulted in greater changes in the lactic acid metabolism in scorbutic guinea pigs than in normal. Concurrently, it was shown that muscle work in trained guinea pigs on a normal diet did not result in an accumulation of lactic acid, but in scorbutic guinea pigs which were trained, similar work always resulted in a considerable accumulation of lactic acid. In scorbutic animals, training does not result in an improvement of the synthetic processes of muscle. These observations supplemented the results of experiments in which the effects of a vitamin C-free diet on the reductive capacity of trained and fatigued muscle was studied.[6] Experiments showed that the lack of vitamin C resulted in a more rapid onset of fatigue and that training under such adverse nutritional conditions had less effect on the ultimate work capacity of such a muscle.

Similar results were obtained on pigeons fed on a thiamin-free diet. Preliminary training did not produce the favorable effects on oxidation reduction processes as resulted in the case of birds fed on a high thiamin diet.[10] Similarly, in pigeons on a thiamin-free diet muscle work resulted in a considerable accumulation of lactic acid, both in trained and untrained animals. Pigeons on the normal diet, but previously trained, when subjected to similar conditions of work did not show an accumulation of lactic acid in muscle. It is to be concluded, therefore, that deficiencies of ascorbic acid and thiamin affect the biochemical processes of muscle produced by training or by fatigue.

Diets were next investigated which were not vitamin free but which were acid or alkaline—normal in all respects except for the predominance of inorganic anions in some and in organic cations in others. On the basis of our experiments with phenol under fatiguing work and with various diets, we found[13] that work on an acid diet interrupted to a lesser degree the oxidation of phenol than synthesis of its detoxication product, but it interrupted these processes to a greater degree when on an alkaline diet. While the general applicability of these findings to all oxidation processes is not to be inferred, they none the less provide a foundation for the concept that the synthetic and oxidative-reductive processes in muscle, as altered by fatiguing work, may be further varied by the alkaline- or acid-forming nature of the diet. Similar results were obtained in studies of the metabolic processes of muscle tissue. The experiments of Guly show[23] that training does not have the same effect on the reduction capacity of rabbit muscle on both alkaline and acid diets. Training to a greater degree improved the oxidation-synthetic processes of rabbit muscle on an acid-forming diet than on an alkaline-forming diet. In the same way, fatiguing work inhibits glycolysis to a great extent, alters the permeability of cell membranes and upsets the water balance of rabbits on an alkaline diet more than in the case of those maintained on a diet of acid-forming substances.[24] All our experiments[10] thus show that the dietary ingredients in respect to quantity of vitamins and preponderance of inorganic anions or cations have a great influence on muscle metabolism, *viz.*, on changes in carbohydrate metabolism, in oxidative and synthetic processes brought about by training and fatigue in muscle and on the work capacity of muscle. These observations bring forth for further elucidation an important theoretical and practical problem—whether by varying the diet it is possible to make the muscle more receptive for training, for more rapidly increasing its work capacity or for delaying the onset of fatigue.

OBITUARY

GEORGE DAVID BIRKHOFF

MIDDAY on Sunday, November 12, 1944, George Birkhoff and his wife were preparing to go over to their son Garrett's. He was ready a quarter to half hour before time to leave and took the occasion to lie down. It was not that he felt badly, but incident to a minor illness in the preceding spring he had been advised to take it a bit easier now he was sixty and in particular to lie down a little while in the middle of the day whenever possible—as so many good doctors advise so many older patients—and being the conscientious person he was, wishing to do the right thing by his doctor, his family, his university and his science, he took that particular opportunity, as he had taken others, to follow the advice. A little later when his wife went to get him to go, he was dead.

[23] N. F. Guly, *Ukrainian Biochem. Jour.*, 9: 2, 1936.
[24] *Ibid.*, 11: 3, 1938.

Thus passed America's leading mathematician, who had been recognized here and abroad more widely than any other mathematician America has yet produced.

We had seen him around as usual during the autumn. It was only a few days since he had been in my office to correct proof on an article in the Proceedings of the National Academy of Sciences and had left with the remark that he had another which he expected would be ready in a few weeks. He could be seen at the meeting of the Faculty of Arts and Sciences the previous Tuesday sitting at the back of the room, thoughtful and smiling. He had attended a meeting of a scientific dining club on Friday and had participated interestedly in the discussions. And on Sunday a coronary thrombosis snuffed out his life. His light will long shine on.

Of especial interest to readers of SCIENCE must be Birkhoff's services to the American Association for the Advancement of Science. He was elected president in 1937—the first mathematician to be so honored since E. H. Moore, under whom he took his doctorate. I would refer to the sympathetic appreciation of the new president written by H. S. White.[1] Reference should also be made to his presidential address, "Intuition, Reason and Faith in Science" printed in SCIENCE, December 30, 1938 (Vol. 88, pp. 601–609). Birkhoff remained on the executive committee of the association from 1938 to 1942. In 1938 he was one of a committee of three, the other two being F. R. and H. G. Moulton, in attendance at the meeting of the British Association for the Advancement of Science charged with discussing with that association the possibility of establishing closer relations with the American Association than had existed in the past. He had been vice-president for the section on mathematics and astronomy in 1918, and in 1926 had received the $1,000 prize for a distinguished paper presented at the meeting of that year, his paper being entitled "Mathematical Criticism of Some Physical Theories." A useful, if little known service of Birkhoff to the association during recent years was his frequent and carefully considered advice to the editor of SCIENCE in respect to appropriate reviewers of books on the branches of science with which he was familiar.

In one of the last papers Poincaré wrote he mentioned a theorem which he believed to be true but which he had been unable to prove. It was this: If an incompressible fluid is moving in two dimensions in the ring-shaped area between two concentric circles and if its motion is clockwise (though not necessarily uniform) along one of the circles bounding the ring but counterclockwise along the other, then there must be at each instant at least one point of the fluid which is at rest. Birkhoff proved that theorem, and received a great deal of recognition therefor, albeit some of his previous papers may have been even greater accomplishments.

Nearly twenty years later in 1937 Birkhoff stated and proved his Ergodic Theorem. As simple an explanation of this result as I know is that he himself gave in the *American Mathematical Monthly,* vol. 49, pp. 222–226, 1942, under the title: "What is the Ergodic Theorem?" The ergodic hypothesis had long been used by leading workers in the kinetic theory of gases and in statistical mechanics. The statement of the hypothesis, like that of many others in applied mathematics, though sufficiently clear for the purposes in hand, had not been given the precision necessary for a mathematically strict proof. It was a great achievement to find a proper precise formulation for and to give a proof of the ergodic theorem, which Wiener and Wintner have characterized as "the only result of real generality established for the solutions of dynamical equations." The applications of the theorem are numerous.

In 1935 Professor Birkhoff was appointed acting dean of the Faculty of Arts and Sciences of Harvard University for the ensuing academic year and a year later he was given a three-year appointment as dean.[2] When he was in college this deanship was held by some distinguished professor and was largely an honorary and advisory position involving little administrative detail. During the presidency of Mr. Lowell, first under Clifford Moore and then under Kenneth Murdock, the office had become a really important part of the central administration of the university, comparable to the academic vice-presidency or the provostship of other universities. When I heard of Birkhoff's appointment I remarked to him that I thought it was too bad for him to sacrifice the better part of his time and strength to this executive position. He replied that he understood that the

[1] *The Scientific Monthly,* February, 1937, vol. 44, pp. 191–3. In this article White says that Birkhoff had quite recently been advanced to the rank of research professor. I can not find any such item in the official record of the university. The reference may have been to his becoming Perkins professor of mathematics in 1933 on the retirement of Osgood, who held that chair in succession to Benjamin Peirce, James Peirce and Byerly. The title generally goes to the leading active professor of mathematics but does not imply a research professorship.

[2] In the *Harvard University Gazette,* vol. 40, No. 42, pp. 171–2, there is printed the Minute on the life of George David Birkhoff prepared by R. B. Merriman, P. W. Bridgman, J. H. VanVleck and J. L. Coolidge (chairman) and placed upon the records of the Faculty of Arts and Sciences at the meeting of April 17, 1945. In this minute is stated: "From 1937 to 1939 he assumed the arduous and important task of serving as Dean of the Faculty of Arts and Sciences." The dates I give are taken from the official records of the university.

new president was planning to make changes in administration which would reduce the office back to its earlier status, that it would take only a few hours a week and that he felt it his duty to make this relatively small sacrifice to aid his new president with many of whose ideas and ambitions he was himself in whole-hearted agreement. For four years he labored and undoubtedly sacrificed much more in time and strength than he had expected. The office was not returned to its earlier status; Birkhoff was succeeded by a practically full-time dean and two, perhaps half-time, assistant deans. In matters social it seems often to eventuate that the effort to displace a system in one direction results in the system executing a displacement in the contrary direction.[3]

When George Birkhoff was starting out as a mathematician the first strong group of pure mathematicians which we have had in this country was supplanting, and even trying to suppress, the applied mathematicians who had dominated American mathematics. No doubt it was high time that modern pure mathematics was given more attention in the United States. When Birkhoff came to Harvard from Princeton in 1912 he came as an analyst. I remember some of the sharp discussions and violent differences of opinion among the Harvard mathematical professors at the time. All rated him very high in analysis; some wanted him in Harvard for that reason alone, others thought Harvard already strong enough in that field and felt that it would be better to strengthen Harvard in some other branch of pure or applied mathematics. It is indeed a matter of inevitable disagreement whether a university department should be sharply specialized in some one main line of activity or be spread generally over several important lines.

As a matter of fact it would be hard to say whether in his thirty-two Harvard years, 1912–1944, Birkhoff was more the analyst or the applied mathematician; he returned to the great tradition. Of his four books —"Relativity and Modern Physics" (1923), "The Origin, Nature and Influence of Relativity" (1925), "Dynamical Systems" (1928), "Aesthetic Measure" (1933)—three certainly and perhaps all four would be classified as applied mathematics. Meanwhile he continued to publish contributions to pure mathematics in the leading mathematical journals of the world. At the time of his death he had in press in France a monograph on auto-equivalent functions and was publishing here upon his theory of gravitation.[4]

If I were to emphasize any personal trait of the Birkhoff I knew for forty years, it would be his keen esthetic sense. It was that which led him to write on esthetic measure, but it showed equally in his mathematics and in his daily life. He was an artist, a simple, generous, zestful artist. Everybody seemed to like him and those who conferred honors upon him seemed to take as great pleasure in giving as he in receiving. I shall not list his many honorary degrees and prizes but must mention that he was personally known and welcome not only in his own country but in Europe, in Asia and in Latin America.

EDWIN B. WILSON

HARVARD UNIVERSITY

[3] For an inanimate system regulated by thermodynamics or statistical mechanics—and the ergodic theorem—we have the principle of LeChatelier that every system in stable equilibrium experiences from the variation of any single one of the factors which maintain the equilibrium a transformation in a direction such as, if it occurred by itself, would bring about a variation of the factor in the opposite direction, *i.e.*, a variation of one of the factors which have to do with a stable or neutral equilibrium can not have as ultimate effect a change of which the direction is opposite to the infinitesimal change with which the disturbance starts. Indeed, some have maintained that this principle is really the definition of stable equilibrium and in essence goes back to Hippocrates. If we displace a body from a position of unstable equilibrium, it is considered as a definition of the instability that the body will persist of itself in moving further in that direction. The phenomenon which so often appears to take place in a social system in that the reaction reverses the displacement one has attempted to impose upon it would therefore seem, at least superficially, to be something different in kind from the phenomenon of deviations from equilibrium (stable, neutral or unstable) in inanimate systems. Possibly when the dynamics of biological and social change shall have advanced to an adequate state of development some future Birkhoff will find and prove some super-ergodic theorem that will be a basic bit of mathematics in the statistical mechanics of such systems.

RECENT DEATHS

DR. HENRY B. WARD, professor of zoology, emeritus, of the University of Illinois, died on November 30 at the age of eighty years.

DR. HANS FREDERIK BLICHFELDT, professor emeritus of mathematics of Stanford University, died on November 16 at the age of sixty-nine years.

JACOB DAVID TAMARKIN, professor of mathematics, who was on leave of absence from Brown University, died on November 18. He was fifty-seven years old.

DR. CHARLES A. VAN VELZER, emeritus professor of mathematics of Carthage College, from 1881 to

[4] See, Proc. Nat. Acad. Sci., Washington, vol. 30, Oct. 1944, pp. 324–334. Birkhoff replaced the curved space-time of Einstein by a flat space-time, using 4-vectors in place of tensors. If we regard physical theory as a convention adopted as a convenience in correlating the main facts of observation in some domain of science, we must admit that a change in any widely accepted theory may well be at first an inconvenience even though it prove in the long run to be a convenience because of its greater simplicity or because of its greater coverage of the facts. Thus only the future can determine the place that may be assigned to this latest, and unhappily last, of Birkhoff's contributions to science, but there are some of his pupils and friends who rate it very highly and will be active in pursuing its implications.

1906 professor of mathematics at the University of Wisconsin, died on November 19 at the age of ninety-four years.

THE death is announced at the age of sixty-six years of Dr. Clarence S. Yoakum, professor of personnel management, dean of the Graduate School and vice-president of the University of Michigan.

DR. LOUIS MAXWELL POTTS, research engineer of the Teletype Corporation, Chicago, died on October 23 at the age of sixty-nine years.

SCIENTIFIC EVENTS

ROYAL SOCIETY MEDALISTS

THE King of England has approved the recommendations made by the council of the Royal Society for the award of the two Royal Medals for the current year as follows:

To Professor J. D. Bernal, F.R.S., for his work on the structure of proteins and other substances by x-ray methods, and for the solution of many other problems requiring a physical approach.

To Dr. E. J. Salisbury, C.B.E., F.R.S., for his notable contributions to plant ecology and to the study of the British flora generally.

The following awards of medals have been made by the president and the council of the Royal Society:

The Copley Medal to Dr. O. T. Avery, For. Mem. R.S., for his success in introducing chemical methods in the study of immunity against infective diseases.

The Davy Medal to Professor Roger Adams, for his extensive researches in the field of organic chemistry and of his recent work in the alkaloid field.

The Hughes Medal to Professor B. F. J. Schonland, O.B.E., F.R.S., for his distinguished work on atmospheric electricity and of his other physical researches.

JOHN D. GRIFFITH DAVIES,
Assistant Secretary

THE PROMOTION OF SCIENCE BY THE GOVERNMENT

A SPECIAL meeting was called on Monday, November 19, by the Western Reserve University Chapter of the Society of Sigma Xi for consideration of the bills now before Congress on governmental promotion of science. The Case Chapter of Sigma Xi and the Cleveland Physics Society cooperated in the meeting, which was attended by seventy-five scientists of the Cleveland area. The program, under the chairmanship of Dr. Helen A. Hunscher, president of the Western Reserve Chapter, was as follows:

1. Summary of Vannevar Bush's Report to the President. H. S. Booth, professor of chemistry, Western Reserve University.
2. Discussion of the need for federal support of research and of the merits and dangers of the proposed bills. Discussion leaders:
   W. G. Leutner, president of Western Reserve University
   Webster G. Simon, educational vice-president of Western Reserve University
   Elmer Hutchisson, dean of the Case School of Applied Science
   Leonard O. Olsen, associate professor of physics of the Case School of Applied Science and president of the Cleveland Physics Society
   A. Sidney Harris, associate professor of physiology of Western Reserve University, chairman.
3. Recommendations of the Western Reserve Chapter Committee on Science Legislation.

The recommendations presented in part 3 of the program had already been sent under the signatures of the committee to President Truman, Senators Magnuson, Kilgore, Taft and Huffman, and to Mr. John Teeter, executive secretary for Senator Magnuson in organizing the hearings. These recommendations, as given below, were endorsed without dissent by those present at the meeting.

To the Senate Subcommittees which are conducting Hearings on Science Legislation

The undersigned members of the Committee on Science Legislation of the Western Reserve University Chapter of Sigma Xi submit the following statement of recommendations:

For reasons which have been ably stated by Dr. Vannevar Bush in his report to President Truman, "Science, the Endless Frontier," we strongly endorse the principle that a National Research Foundation for Federal promotion and support of scientific research be established.

After having studied the several bills for the establishment of a national organization or foundation, we recommend and urge that the bill which is finally reported to the Congress for adoption shall contain, among others, the following provisions.

1. That the powers of the foundation shall be vested in a board of nine members appointed by the President on the basis of a demonstrated capacity for the job and without regard for political affiliation. The director should be appointed by the board.
2. That researches shall be supported through contracts, grants or other forms of assistance. We oppose the principle that support shall be available to nonprofit institutions on a rigid contract basis only.
3. That the foundation, like other government agencies, be given the power to negotiate such patent arrangements with research contractors and grantees

as particular situations may require in the public interest.

Since these provisions are contained in the Magnuson Bill, and since other provisions of this bill are, in our judgment, equal or superior to parallel provisions in other proposed bills, we hereby endorse the Magnuson Bill and recommend its enactment. Before this bill is enacted, however, we recommend two additions which are in the nature of safeguards:

1. To insure that the appointments to the board shall be nonpolitical and based upon ability, they should be made from a list of names submitted by the National Academy of Sciences or other national body or bodies of scientists representing all major fields.
2. To protect the freedom of scientists to choose the nature, scope, and methods of their researches, a specific statement for this purpose should be written into the bill.

If a compromise bill is to be worked out, we urge that the provisions named above and the recommendations of Dr. Vannevar Bush in "Science, the Endless Frontier," and in his testimony before the Subcommittee of the Senate, be included in the new bill.

(Signed) A. SIDNEY HARRIS, *Chairman*
A. H. HERSH
FRANK HOVORKA
FREDERICK R. MAUTZ
HARRY GOLDBLATT

REPORT OF GENERAL ARNOLD ON THE NEED FOR MAINTAINING ADEQUATE AIR POWER

IN the report to the Secretary of War of General Henry H. Arnold, Commander in Chief of the United States Army Air Forces, among the recommendations made are the following:

The Air Force must be authorized to expand existing research facilities and create and take advantage of new ones to accomplish applied research and to make such facilities available to scientists and industrial concerns working on problems for the Air Force. Further, the Air Force must have the means of recruiting and training personnel who have full understanding of the scientific facts necessary to procure and use the most advanced equipment. Although basic scientific research should not be undertaken by the Air Force in its own organization, it must encourage and sponsor such basic research as may be deemed necessary for the defense of the nation. We must depend on scientific and technological advances requiring us to replace about one fourth of our equipment each year.

In the accomplishment of its fundamental responsibility for insuring that the nation is prepared to wage effective air warfare, the Air Force must be able to call on all talents and facilities existing in the nation and sponsor further development of the facilities and creative work of science.

It is in the national interest to establish a national research foundation composed of the most highly qualified scientists in the United States and charged with the responsibility of furthering basic research and development in all fields of science and the scientific training of adequate numbers of highly qualified men. Scientific planning must be years in advance of the actual research and development work.

RECENT GIFTS TO THE ARNOLD ARBORETUM OF HARVARD UNIVERSITY

UNDER the provisions of the will of the late Miss Marian Roby Case, the Arnold Arboretum of Harvard University is named as beneficiary to the extent of her real estate, about 90 acres and all improvements, in Weston, Mass., $150,000 to its capital account, and also the residuary legatee for the entire estate. The indications are that this may prove to be the largest single gift to the Arnold Arboretum in the seventy-three years of its existence. Title has already been taken to the real estate involved which adjoins the sixty-acre estate presented to the Arnold Arboretum three years ago by the decedent's sister, Miss Louisa W. Case, together with an outright gift of $50,000 to capital. While no restrictions were specified, the hope was expressed that with the additions to institutional income the two adjoining estates could be maintained and developed as an adjunct to the Arnold Arboretum.

The will of the late Mrs. Katherine T. Balch, wife of the late John Balch, of Milton, Mass., now in probate, provides that the Arnold Arboretum is to be the recipient of one half of her residuary estate, which may amount to more than $100,000.

SCIENCE AWARDS OF THE GUGGENHEIM FOUNDATION

THE John Simon Guggenheim Memorial Foundation has awarded thirty-six post-service fellowships amounting in value to $94,000 to young scholars and artists who have served in the Army and in other Government services. The recipients, each granted approximately $2,500, range from private first class, to lieutenant colonel, and, in the Navy, from specialist third class, to lieutenant commander.

The original appropriation of $200,000 for post-service fellowships, which are granted on the same basis as the other fellowships of the foundation to those who have demonstrated unusual capacity for research and artistic creation, was doubled. This was done because of the high ability of the applicants.

Awards in the sciences are as follows:

Dr. Lewis H. Kleinholz, Captain, Army; instructor, Cambridge (Mass.) Junior College—Studies of physiological and chemical interrelationships in the fields of crustacean endocrinology.

Dr. G. La Verne Freeman, Lieutenant Commander, Navy; associate professor of psychology, Northwestern

University—The preparation of a book on nervous tension in man.

Dr. E. Yale Dawson, Captain, Army; assistant in botany, University of California—Exploration of the Pacific coast of Mexico and Central America for marine algae and the continuation of monograph studies of the marine flora of that region.

Dr. Harold F. Blum, principal biophysicist, Naval Medical Research Institute, Bethesda, Md.—An evaluation of evolutionary concepts, with special emphasis on physiological and environmental aspects.

Dr. Orville T. Bailey, pathologist, Harvard Medical School; War Research under OSRD contract—Studies of the application of physiological methods to problems of degeneration in nerve fibers and myelin sheaths, in correlation with cytological studies.

Dr. Roy Overstreet, assistant soil chemist, Division of Soils, and research associate, Radiation Laboratory, University of California—A study of the absorption and behavior of inorganic ions in plant nutrition by means of radioactive elements and the preparation of radioautographs of the plant tissues.

Dr. George L. Kreezer, associate professor of psychology, Cornell University; staff member, Radiation Laboratory, Massachusetts Institute of Technology—Mathematical analysis of physiological regulatory systems on the basis of physical automatic control theory.

Walter H. Pitts, mathematician; staff member, Radiation Laboratory, Massachusetts Institute of Technology—Studies of the mathematics of the nervous system.

Dr. Britton Chance, assistant professor, School of Medicine, University of Pennsylvania: Doing War Research under OSRD contract—An experimental study of the chemical kinetics of the respiratory enzymes.

Dr. Charles Kittel, physicist; supervisor, Submarine Operations Research Group, Navy—Studies of the theory of the electrical and mechanical properties of matter at microwave radio frequencies.

Dr. Lindsay Helmholz, assistant professor of chemistry, Dartmouth College; chemist working on War Department contract—a study of absorption spectra and structures of solids with the purpose of finding relations that will make possible wider use of absorption data in obtaining information of chemical importance concerning crystals and their constituent atoms or ions.

THE AMERICAN ACADEMY OF TROPICAL MEDICINE

THE twelfth annual meeting of the American Academy of Tropical Medicine was held on November 14 at Cincinnati, Ohio, in conjunction with the Southern Medical Association and the American Society of Tropical Medicine. Dr. E. V. Cowdry, of Washington University, St. Louis, Mo., served as toastmaster. Dr. Mark F. Boyd, Rockefeller Foundation, Tallahassee, Fla., delivered the presidential address. His subject was "International Appraisal of Tropical Medicine." Dr. Louis van den Berghe, of the Belgian Institute of Tropical Medicine, Antwerp, spoke on "The Importance of Tropical Medicine in International Health and Economics."

The following were elected to membership in the academy: Leon A. Fox, M.C., U.S.A.; Clay G. Huff, University of Chicago; Henry Pinkerton, St. Louis University; Paul W. Wilson, M.C., U.S.N., and Willard H. Wright, National Institute of Health, Bethesda, Md.

The following were elected to emeritus membership: R. C. Connor, Charles A. Kofoid, Ernest L. Walker and George H. Whipple.

Officers and councilors elected for the ensuing year are as follows:

President, James S. Simmons, M.C., U.S.A.
Vice-president, George K. Strode, Rockefeller Foundation.
Secretary, Ernest Carroll Faust, Tulane University.
Treasurer, Thomas T. Mackie, M.C., A.U.S.
Councilor (5-year term), L. T. Coggeshall, M.C., U.S.N.(R).
Councilor (3-year term), Karl F. Meyer, Hooper Foundation, San Francisco.

ERNEST CARROLL FAUST,
Secretary

NEWS FROM ABROAD

THE following information has been received by Dr. R. C. Mason, of the Research Laboratories at Pittsburgh of the Westinghouse Electrical and Manufacturing Company, from Dr. H. Brinkman concerning the laboratories of physics in Holland.

. . . In Amsterdam, the Germans stole many instruments, especially the high tension apparatus and the neutron generator tube from the physical institute of Dr. G. T. Sizoo, who is working on radioactive and nuclear physics problems. Some instruments were taken from Leiden, but other university laboratories (Utrecht, Amsterdam, Groningen and the Technical High School at Delft) suffered no permanent loss, as practically all apparatus was concealed in cellars of buildings, churches, etc. The same is true of the research laboratories of the Shell Company at Amsterdam, and the Phillips Company at Eindhoven. The Agricultural High School at Wageningen was heavily looted, and the laboratories of the N. V. KEMA (Electrical Testing Laboratories) at Arnhem were completely looted by the Germans between October, 1944, and March, 1945, at a damage of three million guilders.

More than by material losses the universities and high schools suffered personal losses. Several professors and very many students died in concentration camps or because of their illegal (resistance movement) work. For instance, by execution and concentration camps, 150 students and two professors of the Technical High School at Delft alone died. The Dutch Physical Society lost in that way 16 of its members.

On September 29, we had the first gathering of the

Dutch Physical Society after the liberation of Holland. . . .

An earlier letter from the same correspondent brought news of the death of Professor L. S. Ornstein in 1941.

Dr. William Randolph Taylor, of the University of Michigan, writes:

A letter dated October 30, 1945, from C. J. H. van den Broek, who is at present connected with the Central Institute for Food Research, Utrecht, tells of the difficulty of providing instruction during the period of the German occupation for those students who could not attend the Nazi-approved university classes. It also gives an apparently very recent list of Netherlands East Indies biologists, with what was known to date of their fate. To quote:

> In the days your letter came we hadn't heard anything yet about Dutch biologists in the Netherlands Indies, but already there was no asking any more if somebody would still be working, but only if the man was still alive. Since then a letter from Giesberger (from Singapore) to Professor Königsberger has arrived, containing the following list, that I give you completely in case you'd know some one of them:
>
> Living are:
>
Giesberger	Dijkman	Vles
Van Eek	Hart	De Haan
Blomberg	Reitsma	Maas
Van Weel	Sody	Velzen
De Jong	Roelofse	Lieftinck
Pfalzer, Jr.	Van der Pijl	Siebers
Van Wieringen	Van Steenis	De Jongh
Ferwerda	Halsvoogd	Posthumus
B. Polak	Kalis	Douk
Ruinen	Tammes	Van den Honert
Rümke	Toxopeus (two of this name)	Heyn
Weelburg		Pfalzer, Sr.
Clason	Kalshoven	Schuurman
Buwalda	Van Sloten	Boedijn
Korthaus	De Wit	Ommen
Sinia	ten Houte	Hilleris Lambers
	Thomas	

> Dead are:
>
De Groot	Vos	Gandrup
Hardenberg	Van Gennep	Both
Duyfjes	Van der Goot	Booberg
Miss Bolle	Altman	Bos
Ferman	Harteveld	F. Gorter (?)
	Eyma	
>
> As you see [Dr. D.] Hardenberg [Director, Laboratorium voor Onderzoek der Zee, Batavia] is reported dead, but there is another rumor (probably of older date) that he is still alive. I'm sorry that I can't give you any better news—we all are waiting for it now!

Dr. Taylor has also heard from Dr. Mary W. Parke that she has been transferred from the marine station at Port Erin, Isle of Man, where she was resident phycologist, to the station at Plymouth. As is already known, the latter station suffered from the 1941 air raids, but the Port Erin station did not. He also reports that M. P. Bourrelly has been appointed assistant for freshwater algae at the Museum National d'Histoire Naturelle, Paris, to fill one of the vacancies left by the war-time deaths at that institution.

Dr. P. W. Whiting, of the University of Pennsylvania, reports that Professor A. Vandel, of Laboratoire de Zoologie de la Faculté des Sciences, Allées, Saint-Michel, Toulouse, writes that Toulouse has been fortunate in its relative separation from the war and that his laboratory was never struck by air action. Although the investigators have had to undergo severe restrictions and the output of scientific publications has been much retarded, he has nevertheless been able to continue his researches on sex in terrestrial Isopoda. He is pleased to be again receiving foreign publications.

Professor Fr. Fichter, of Basle, Switzerland, writes to Dr. Colin G. Fink, secretary of the Electrochemical Society, Inc., that he retired from his professorship in 1939, had edited a book on electro-organic chemistry which was printed in 1942, and that he is now very active in editing *Helvetica chimica acta,* which "is growing bigger every year." Dr. Fichter is assisted in his editorial work by Mrs. Fichter. He is now 76. His son has spent several years in America and is now returning to Switzerland.

The following letter has been received by Dr. Henry H. Tryon, director of the Black Rock Forest, Cornwall-on-Hudson, New York, from Dr. C. H. Bornebusch, director, Statens Forstlige Forsøgsvaesen, Springforbi, Denmark:

> Your promise to assist us in getting seed from American forest trees I accept with great gratitude. We shall be much interested in obtaining acorns of *Quercus borealis* from trees of good site. Usually the price of American tree seed has been so high that we could only buy for experimental purposes. We should be very happy, if it can be arranged, to obtain several hundred kilos for the experiment station. These should come from different stands and sites which are suitable for our rather low summer temperatures.
>
> We also need a considerable quantity of Douglas fir seed every year. It would mean a great deal to us; it would be a large step forward if some forwarding arrangement could be perfected with the U. S.

Dr. Rousseau H. Flowers, assistant State paleontologist of the New York State Museum, reports that a letter from Dr. Ferdinand Prantl, of the Narodni Museum v Praze, reads:

> I take the liberty to bring to your notice that the National Museum in Prague was very heavily damaged by the Nazi-bombs at the same time or later than the signing of the general capitulation of the German army. The famous collections of Barrande, of which I have the honor to be the keeper, are safe. On the other hand, there were destroyed entirely our working rooms. I have lost many text-books and the greater number of the paleontological reprints and journals.

Dr. Prantl has written requesting reprints, offering his own in exchange. Doubtless any other papers relating to Paleozoic paleontology and stratigraphy would be greatly appreciated.

Bernard D. Davis, assistant editor of the *American Review of Scientific Medicine,* writes:

In line with your policy of providing information on the reconstruction of scientific activities in Europe, you may be interested in the following abstract from an article in the *Bulletin* of the Academy of Sciences of the USSR (Izvestia Akad. Nauk SSSR) Biol. Series No. 2, p. 146 (1945). Written by E. N. Pavlovsky, director of the Zoological Institute of the academy, it concerns the history of this institute, which was founded in 1724 as the Cabinet of Curiosities of Peter the First, subsequently becoming the Zoological Museum in 1837 and the Zoological Institute in 1930.

"During the patriotic war almost all the associates of the (Zoological) Institute were evacuated, mostly to Tadjikistan (Stalinabad). Very energetic and productive work was done in studying the fauna and ecology of Tadjikistan. All the collections and the main funds of the institute were left in Leningrad; they were stored in the basements and the exhibition halls. Five shells which hit the building did not cause great harm so that the collections remained intact. Scores of incendiary bombs were extinguished by the associates of the institute.

"The activities of the Zoological Institute are in full sway. Its main publication is 'Fauna of Russia and the Adjacent Countries.' About twenty-five volumes of these monographs were already issued prior to the Revolution. This edition has been reorganized into the 'Fauna of the USSR.' Over twenty-five volumes have been published and about twenty volumes prepared for the press. Reevacuation of the institute has already begun and the next task is complete reconstruction, which will be accomplished in summer, 1945."

SCIENTIFIC NOTES AND NEWS

DR. DETLEV W. BRONK, professor of biophysics and director of the Eldridge R. Johnson Foundation of the University of Pennsylvania, has been appointed foreign secretary of the National Academy of Sciences. By virtue of this appointment, Dr. Bronk also becomes chairman of the Division of Foreign Relations of the National Research Council.

DR. W. F. HAND has retired as dean of the School of Science of the Mississippi State College and as state chemist, but continues as vice-president of the college. He is succeeded as head of the department of chemistry and as state chemist by Dr. M. P. Etheridge. Dr. Clay Lyle, executive officer of the State Plant Board, head of the department of zoology and entomology, and entomologist for the Experiment Station and Agricultural Extension Service, succeeds Dr. Hand as dean of the school of science.

DR. DONALD G. ANDERSON, who was associated with the distribution of penicillin during the war, has been named dean of Boston University.

DR. WILLIAM B. SARLES, associate professor of agricultural bacteriology at the University of Wisconsin, has been appointed a half-time assistant to the president of the university, Dr. Edwin F. Fred.

DR. H. LEO MARSHALL, professor and head of the department of public health and preventive medicine of the University of Utah, has been named acting dean of the School of Medicine.

COLUMBIA UNIVERSITY and the American Museum of Natural History have concluded arrangements for a mutual plan of instruction and research in vertebrate paleontology. Dr. George Gaylord Simpson and Dr. Edwin H. Colbert, of the American Museum, have been appointed professors of vertebrate paleontology at the university. They will serve in the departments of zoology and geology, respectively. The appointments provide a succession to Dr. William King Gregory, Da Costa professor of zoology, who retired recently. Dr. Norman D. Newell, of Madison, Wis., has been appointed professor of invertebrate paleontology in the department of geology of the university and curator of invertebrate paleontology at the museum.

DR. EMILIO SEGRE has been appointed professor of physics at the University of California at Berkeley. Dr. Segre has been at Los Alamos, New Mexico, since 1943 and expects to take up his professorship within the next few months after completing his work at Los Alamos. Prior to 1943, Dr. Segre was for two years a lecturer in physics at the university.

DRS. DANA PAUL MITCHELL and Norman Foster Ramsey, Jr., of Columbia University, have been promoted to the rank of associate professor of physics. Raymond David Mindlin has been promoted to an associate professorship of civil engineering.

DR. CLAUDE VILLEE has been appointed instructor in biological chemistry in the Harvard Medical School.

AT the University of London, Dr. G. A. H. Buttle has been appointed to the university chair of pharmacology tenable at the College of the Pharmaceutical Society of Great Britain.

DR. J. M. MEEK has been appointed to the David Jardine chair of electrical engineering (electronical) at the University of Liverpool.

DR. EDWARD A. STEINHAUS, assistant professor of bacteriology, recently joined the staff of the Division of Entomology and Parasitology of the University of California at Berkeley to carry out research in insect pathology in relation to biological control, under Professor Harry S. Smith of Riverside.

LIEUTENANT E. G. STANLEY BAKER, Army Air Forces, formerly assistant professor of zoology at Wabash College, has been released from active duty.

DR. GEORGE TAYLOR, assistant keeper (first class), has been appointed deputy keeper in the department of botany at the British Museum.

DR. PHILIP B. PRICE, professor of surgery at the University of Utah, has been granted by the Givaudan-Delawanna Corporation the sum of $5,250 for an investigation of skin disinfection.

DR. JAMES HENDERSON, lecturer in mathematics at King's College, London, has been appointed academic registrar of the university from January 1, 1946.

AT the Case School of Applied Science, Dr. Robert S. Shankland, on leave for the past three years to the Office of Scientific Research and Development, has returned to his position as head of the department of physics, and Dr. Robert Rinehart, Dr. Charles C. Torrance, Dr. Paul Guenther and Dr. Lewis J. Green have resumed their work in the department of mathematics.

DR. JAMES CURRY has returned to Williams College after having spent over two years at the Radio Research Laboratory of Harvard University. He takes over the chairmanship of the department of chemistry. Dr. Warren C. Lothrop has joined the department as an assistant professor. He will teach organic chemistry. During the war Dr. Lothrop was in Washington and served as a technical aid in the National Research Defense Committee.

DR. BILL ELPERN, who has been working under a National Defense Research Committee contract on anti-malarials at the University of Nebraska during the past year, has recently become senior chemist with the Winthrop Chemical Company, Inc., Rensselaer, N. Y. Dr. Oliver H. Buchanan, research associate in the department of biological chemistry at the Medical School of the University of Michigan, has joined the research staff as a senior investigator.

DEAN HOMER JAY HENNEY, director of the Agricultural Experiment Station of Colorado State College at Fort Collins, has been granted leave of absence for a year to become deputy director of the food and agricultural branch of the military control council in Germany.

A GRANT of $3,000 from the Research Corporation has been received by the University of Pittsburgh to enable an extension of investigations conducted by Dr. Klaus Hofmann, associate research professor of chemistry. The program, which is part of the research in the natural sciences supported by an earlier grant from the Buhl Foundation, is designed to clarify the action of biotin, a vitamin of the B-complex group, the chemical structure of which Dr. Hofmann helped to work out several years ago.

DR. W. S. GILLAM, professor of agricultural chemistry at Purdue University, has joined the staff of the Midwest Research Institute, Kansas City. He will carry on research in soils and plant nutrition and in analytical services.

DR. ROBERT D. COGHILL, Peoria, Ill., chief of the Fermentation Division, Northern Regional Research Laboratory, in Peoria, of the U. S. Department of Agriculture, has become associate research director of the Abbott Laboratories.

DR. GEORGE DE WITT GRAVES and Dr. Robert Emmett Burk have been appointed assistant chemical directors of the plastics department of the E. I. du Pont de Nemours and Company, Wilmington 98, Delaware. Both have been assisting John L. Brill, chemical director of the department. They now will have charge of all phases of research in plastics under Mr. Brill.

C. H. ACHESON, formerly party chief of gravity meter work in Columbia and later in western and northwestern Canada, has been transferred to Ecuador, to take up the position of gravity meter supervisor for the International Ecuadorian Petroleum Company in Guayaquil.

THE psychological staff of Stevenson, Jordan and Harrison, Inc., management engineers, has been in process of reorganization since September. The Chicago office has recently added Dr. Eleroy L. Stromberg and Dr. L. René Gaiennie, of the Branch of Aviation Psychology of the Bureau of Medicine and Surgery of the Navy Department, to its staff. Both Dr. Stromberg and Dr. Gaiennie had been placed on the inactive list.

DR. JULIAN HUXLEY, secretary of the Zoological Society, London, addressed the meeting of the Independent Citizens Committee of the Arts, Sciences and Professions that was held at Madison Square Garden, New York City, on December 4, to discuss the atomic bomb.

PROFESSOR CLAUDE E. ZOBELL, of the Scripps Institution of Oceanography, delivered on November 15 an address entitled "Microbial Transformation of Petroleum Hydrocarbons," at the three hundred and thirty-sixth meeting of the Washington Academy of

Sciences, which was held jointly with the Geological Society of Washington.

DR. F. C. BISHOPP, assistant chief of the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture, addressed a joint meeting in New York of the New York University Medical Society and the New York University Chapter of Sigma Xi on November 11. He spoke on "Insect Control—War and Post-War Developments."

DR. K. LINDERSTRØM-LANG, of the Carlsberg Laboratories in Copenhagen, and Dr. Ernst Bergmann, of the Sieff Institute in Jerusalem, spoke before the Organic Chemistry Seminar of Fordham University on November 2 and 14, respectively. Dr. Linderstrøm-Lang reported on "Recent Advances in Microbiological Methods," and Dr. Bergmann discussed "Walden Inversion and Racemization Reactions."

PROFESSOR WILBUR M. WILSON, of the department of civil engineering of the University of Illinois, spoke at Iowa State College, Ames, at a Sigma Xi dinner and initiation on November 27. His lecture was entitled "Notes from the Diary of a Research Engineer."

THE third annual D. J. Davis Lecture on medical history of the College of Medicine of the University of Illinois at Chicago was delivered on November 21 by Dr. Carl E. Black. He spoke on "Medical Practice Before the Hard Roads."

AT the fall dinner on November 13 of the Smith College chapter of the Society of the Sigma Xi, Dr. Henry Allen Moe, secretary-general of the Guggenheim Memorial Foundation, was the guest speaker. His subject was "Proposed Government Plans for the Discovery and Development of Scientific Talent." Dr. Marjorie Williams, of the department of astronomy, is president of the chapter for the coming year.

THE four hundred and thirteenth meeting of the American Mathematical Society was held at the California Institute of Technology on November 24. By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, Professor Hans Lewy, of the University of California, Berkeley, delivered an address entitled "Water Waves on Sloping Beaches."

THE Federation of American Societies for Experimental Biology will meet in Atlantic City beginning on Monday, March 11, 1946. The federation is composed of the American Physiological Society, the American Society of Biological Chemists, the American Society for Pharmacology and Experimental Therapeutics, the American Society for Experimental Pathology, the American Institute of Nutrition and the American Association of Immunologists.

A STATEMENT setting forth their position on the international control of atomic energy has been made public by five hundred and fifteen physicists, chemists and engineers who were engaged in war research at Harvard University and the Massachusetts Institute of Technology. A summary of this statement reads: "Specifically our conclusions are: (1) Other nations will be able to produce atomic bombs; (2) no effective defense is possible in atomic warfare; (3) safety can not be obtained by superiority in atomic armament; (4) henceforth, war will mean the destruction of a large fraction of civilization; (5) international cooperation of an unprecedented kind is necessary for our survival."

THE French Press and Information Service reports that a new ordinance, appearing in the *Journal Officiel,* establishes a committee for atomic energy. It is stated in the preamble: "Urgent national and international necessities have obliged the taking of the requisite measures, so that France may hold her place in the field of research in atomic energy." This organization will include a small committee which will act as a board of management and at the same time act as a working group in scientific research. Scientific and technical work will be directed by a high commissioner. A general manager representing the Government will be placed at the head of the administrative and financial management of the commission. Three investigators in atomic research and the president of the coordinating committee of national defense research work will be appointed members of the commission, which will be presided over by the president of the Provisional Government. The commission's freedom of action is guaranteed by the fact that its creation is regulated by civil and commercial law.

SPECIAL ARTICLES

THE ROLE OF AMINO ACIDS AND AMIDES IN THE METABOLISM OF AMMONIUM ABSORBED BY ZEA MAYS L.[1]

ONE or the other, and sometimes both, of the acid amides, asparagine and glutamine, have been known for many years to accumulate in plants when ammonium is absorbed from the substrate or when the

[1] Published with the approval of the director of the South Dakota Agricultural Experiment Station as Journal Paper No. 198.

environment is unfavorable so that protein hydrolysis occurs and the amino acids are deaminized to produce ammonia. The latter condition occurs when seedlings or excised leaves are cultured in the dark. Boussingault[2] and later Prianischnikow[3] considered this amide formation to be a detoxicating mechanism for ammonia, but recently Chibnall[4] and Vickery and Pucher[5] considered it to be a regular phase in the respiratory mechanism of the plant.

Other methods of utilizing excess ammonia have been suggested: (1) the storage of ammonium as the cation of organic acids by Ruhland and Wetzel[6] in plants with acid saps, (2) formation of arginine in the conifers as suggested by Susuki[7] but later questioned by several investigators, and (3) the formation of urea by certain higher plants and the fungi.

In connection with studies on the nitrogen metabolism of corn, more information was needed on the nature of the compounds formed in response to the absorption of ammonium or its release by catabolic processes in the tissues. Boussingault[2] noted the presence of asparagine in corn when he compared the formation of this amide to the detoxication of ammonia as urea in animals. Prianischnikow[8] demonstrated that the presence of carbohydrate was essential for the formation of asparagine in corn. Asparagine was crystallized from etiolated corn seedlings by Jodidi,[9] but he did not report the presence of glutamine. According to Klein and Taubock,[10] urea does not occur in corn and the writer has been unable to demonstrate its presence in mature plants.

Experimental

The plan was to produce plants low in soluble nitrogen compounds and high in sugars by limiting the supply of nitrogen during the preliminary growth period; and then to force them to absorb ammonium until toxicity symptoms appeared, measuring the changes in certain constituents during this period of enforced ammonium absorption.

South Dakota hybrid 105 × 107 seeds were planted in sand, and when the plants were about 10 cm high, they were transplanted to crocks (3 per crock) each containing 7 liters of one-half strength Hoagland solution supplemented with the essential microelements. $FeSO_4$ was added in solution semiweekly throughout the entire investigation. On January 2, when the plants were 18 inches high, the solution was replaced by a similar solution except that nitrogen was omitted, the Ca and K being added as the sulfates. At the end of 7 days, the lower leaves were showing definite nitrogen deficiency symptoms along the midrib, and the soluble nitrogen constituents of the expressed sap had been reduced to a low level as shown by subsequent analyses (0 days, Table 1) of 6 plants calculated to a 12-plant basis.

TABLE 1

Influence of Ammonium Absorption on Various Constituents of Tops of 12 Corn Plants

Days		0	3	6	13
meq/l $(NH_4)_2SO_4$ in solution for preceding interval	....	0	30	60	120
Dry wt. (g)	.....	27.4	27.7	38.8	44.5
Total N (mg/g)	.....	26.5	28.4	30.3	34.8
Total sugar (per cent. dry wt.)		5.00	6.12	6.46	5.62
"True protein" (mg N/g)	....	18.8	21.2	18.8	18.8
pH of sap	.....	6.6	6.7	6.9	6.9
NH_3 and NH_4^+ (mg N/l)	....	15.2	14.6	18.9	100
Glutamine	"	27.2	43.8	99.0	328
Asparagine	"	37.2	107	249	588
α-amino	"	155	161	201	380
Undetermined	"	...	515	904	1,592
Total soluble	"	...	842	1,472	2,988

Thirty meq/l of $(NH_4)_2SO_4$ were added to the remaining solutions, and after 3 days, 12 more plants were harvested. The $(NH_4)_2SO_4$ concentration of the remaining solutions was then increased to 60 meq/l, as indicated in Table 1. This procedure was continued until the final set of plants was in 120 meq/l of $(NH_4)_2SO_4$. On the 13th day the remaining plants began to wilt, the leaves rolled and the tips began to die. During this period of rapid ammonium absorption, the solution pH remained at 6.5 ± 0.1.

At harvest the plants were separated into roots and tops, and the roots were washed in distilled water. Fresh weights were taken, the material cut into one-inch lengths, thoroughly mixed, one third dried for moisture, sugar, total N and "true protein" determinations, and the remaining portion wrapped in cheesecloth, frozen, slowly thawed, and the sap expressed in a hydraulic press at 2,600 lbs./sq. in.

Analytical Methods

Dry material: total sugars were determined by the procedure of Hassid.[11] Total N and "true protein N" were determined by the Kjeldahl method, the latter after extracting the dried material with 80 per cent. ethanol for 6 hours followed by boiling water.

Sap constituents: ammonia, glutamine, and as-

[2] J. B. Boussingault, *Agronomie, chemie agr. et physiol.*, 4: 245, 1868.

[3] D. Prianischnikow, *Ber. bot. Ges.*, 40: 242; *ibid.*, *Biochem. Z.*, 150: 407, 1924.

[4] A. C. Chibnall, "Protein Metabolism in the Plant." New Haven, 1939.

[5] H. B. Vickery and G. W. Pucher, *Jour. Biol. Chem.*, 128: 703, 1939.

[6] W. Ruhland and K. Wetzel, *Planta*, 1: 558, 1926; *ibid.*, 3: 765, 1927; *ibid.*, 7: 503, 1929.

[7] U. Susuki, *Bull. Coll. Agric, Tokyo*, 4: 1, 25, 1900–1902.

[8] D. Prianischnikow, *Landw. Vers. Sta.*, 99: 267, 1922.

[9] S. L. Jodidi, *Jour. Agr. Res.*, 34: 649, 1927.

[10] G. Klein and K. Taubock, *Biochem. Z.*, 255: 278, 1932.

[11] W. Z. Hassid, *Ind. Eng. Chem., Anal. Ed.*, 9: 228, 1937.

paragine were determined by the procedure of Vickery *et al.*[12] Total soluble N was determined on 3 per cent. trichloroacetic acid filtrates. Van Slyke α-amino N was determined on the deproteinized filtrates after the amides were hydrolyzed for 2 hours with 2N HCl at 100° C. followed by the liberation of the ammonia on the steam bath at pH 7.5.[13] The α-amino N associated with the amides was subtracted from this value to give the α-amino N reported in Table 1.

Since the data from the roots are similar, they will not be given here, except to note that the roots gained only 10 per cent. in dry weight during the experimental period, whereas the tops gained over 60 per cent. during the same period. This experiment has been repeated in the spring season with substantially similar results.

Discussion

The data of Table 1 indicate that the plants absorbed large quantities of ammonium N and made substantial growth. There was no significant trend in "true protein" N, but the nitrogen absorbed in excess of the plant's requirements went into the formation of glutamine, asparagine and one or more amino acids. There was also a great increase of undetermined forms of soluble N. Ammonia does not accumulate in the neutral sap until the amides and other soluble nitrogen constituents have reached a relatively high level. The factor or factors preventing further utilization of this absorbed ammonia are not known, but carbohydrate would not appear to be the limiting factor. It is appropriate to recall Prianischnikow's[14] speculation that ammonia may not always be the toxic agent, but the accumulation of some product arising from the utilization of the ammonia.

That the increase in α-amino N observed here is a net increase and does not come from the degradation of protein is inferred from the stable values for "true protein" N. This role of amino nitrogen has apparently not been appreciated in the past, since in the usual type of experiment with etiolated seedlings or excised leaves the amino acids arise from protein hydrolysis and, hence, their role in metabolizing ammonia can not be appraised. This function of amino N may not be universal, however; for Vickery, Pucher and Clark[15] found that all the ammonia absorbed by the beet was transformed into glutamine.

This rapid synthesis of one or perhaps more α-amino acids offers the possibility of a new approach to the study of amino acid synthesis and protein regulation in the plant.

Summary

When corn seedlings, previously depleted in soluble nitrogen constituents, are forced to absorb large quantities of ammonium nitrogen, soluble compounds accumulate in the sap. Asparagine, glutamine, one or more amino acids and undetermined compounds are synthesized. Ammonia does not accumulate until these constituents have reached a relatively high level.

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EXPERIMENT STATION
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[12] H. B. Vickery, G. W. Pucher, H. E. Clark, A. C. Chibnall and R. G. Westall, *Biochem. Jour.*, 39: 2710, 1935.

[13] Personal communication from T. C. Broyer and D. R. Hoagland, University of California.

[14] D. Prianischnikow, *Z. Pflanzenernahr. Dungung*, 4A: 242, 1925; *ibid.*, *Jour. Russian Botan. Congress*, 1: 65, 1921. (Abstracted in *Chem. Abs.*, 19: 3288, 1925.)

[15] H. B. Vickery, G. W. Pucher and H. E. Clark, *Plant Physiol.*, 11: 413, 1936.

THE EFFECT OF TRANSFUSIONS OF RED BLOOD CELLS ON THE HYPOXIA TOLERANCE OF NORMAL MEN[1, 2]

ONE of the most striking physiologic changes during acclimatization to high altitudes is the development of polycythemia.[3, 4] An artificial polycythemia has been produced in experimental animals by means of cobalt administration and has apparently increased their tolerance to hypoxia.[5] It appeared of interest to learn whether polycythemia induced in normal men by the transfusion of red blood cells would increase their tolerance to altitude hypoxia.

Experimental Procedure

A group of ten normal young men was divided into two groups of five each so that the mean ages and body weights were comparable. During the first two weeks of the experiment, control observations were made on both groups. These consisted of determinations of oxygen capacity of the blood; arterial oxygen (using arterialized venous blood[6]) and carbon dioxide content and pH of the serum at sea level and at a simulated altitude of 15,500 feet in a low pressure chamber; oxygen and carbon dioxide content of alveolar air; total urinary pigments; reticulocyte per-

[1] From the Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Maryland.

[2] The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

[3] D. B. Dill, "Life, Heat and Altitude." Cambridge: Harvard University Press, 1938.

[4] A. Hurtado, C. Merino and E. Delgado, *Arch. Int. Med.*, 75: 284, 1945.

[5] S. S. Dorrance, G. W. Thorn, M. Clinton, H. W. Edmonds and S. Farber, *Am. Jour. Physiol.*, 139: 399, 1943.

[6] S. Goldschmidt and A. B. Light, *Jour. Biol. Chem.*, 64: 53, 1925.

centages; blood volume by the carbon monoxide technic; and pulse rate, respiratory rate and respiratory minute volume responses to exercise, breathing air and various low oxygen mixtures.

From the fourteenth day of the experiment to the seventeenth day inclusive, a total of 2,000 ml of a 50 per cent. suspension in dextrose and saline of red cells prepared from blood drawn less than 24 hours previously was injected intravenously in each of the men in the first group (hereinafter known as the transfused group or T.G.) and a total of 2,000 ml of the dextrose and saline diluent alone was injected intravenously in each of the men in the second group (hereinafter known as the control group or C.G.). Arrangements were made so that no man knew whether he was receiving red cells or dextrose and saline. The above physiological and biochemical observations were then resumed on both groups and continued for two months.

Results

The transfusions of red cells were accomplished without any untoward sequelae other than urticaria in one man. There was neither hemoglobinuria nor increase in total urinary pigments. Both the oxygen capacity and the arterial oxygen content of the transfused group at sea level and at 15,500 feet increased significantly as a result of the transfusions (Fig. 1).

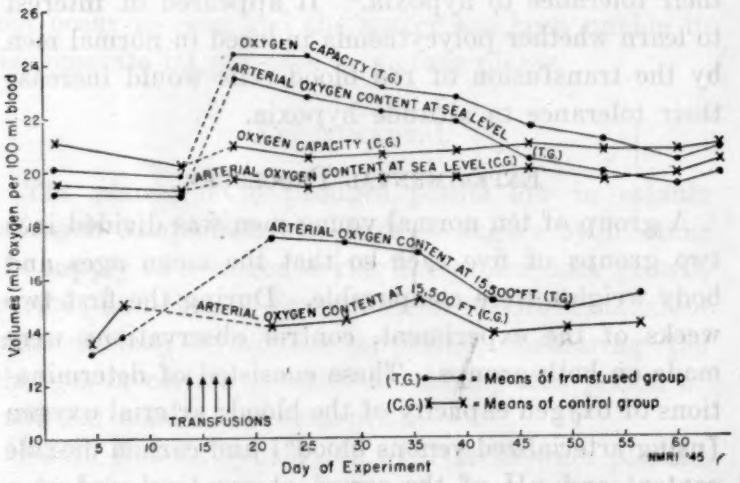
OXYGEN CAPACITY (T.G.)
ARTERIAL OXYGEN CONTENT AT SEA LEVEL
OXYGEN CAPACITY (C.G.)
ARTERIAL OXYGEN CONTENT AT SEA LEVEL (C.G.)
(T.G.)
ARTERIAL OXYGEN CONTENT AT 15,500 FT. (T.G.)
ARTERIAL OXYGEN CONTENT AT 15,500 FT (C.G.)
(T.G.) = Means of transfused group
(C.G.) = Means of control group
TRANSFUSIONS
Volumes (ml) oxygen per 100 ml blood
Day of Experiment
NMRI '45

FIG. 1. Mean blood oxygen capacity levels and arterial oxygen contents at sea level and at 15,500 feet of ten men, five of whom were transfused with 2,000 ml of a 50 per cent. red cell suspension over a period of four days (transfused group) and the remaining five transfused with an identical volume of dextrose in saline solution (control group) over the same period.

One of the most striking observations was that the oxygen saturation of the arterial blood both at sea level and at altitude was unchanged by the transfusions. In other words, the hemoglobin of the transfused red cells as well as of the original cells was being effectively oxygenated. During the polycythemic period the pulse rate following exercise when breathing low oxygen mixtures was significantly lower than control measurements (Fig. 2). The pulse rate

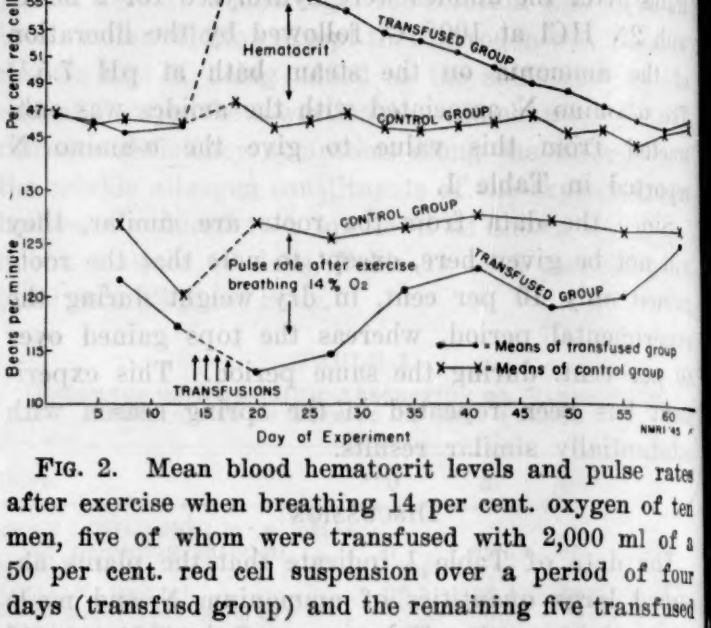

FIG. 2. Mean blood hematocrit levels and pulse rates after exercise when breathing 14 per cent. oxygen of ten men, five of whom were transfused with 2,000 ml of a 50 per cent. red cell suspension over a period of four days (transfusd group) and the remaining five transfused with an identical volume of dextrose in saline solution (control group) over the same period.

following exercise at simulated altitude appears to be an objective method of determining hypoxia tolerance in groups of subjects. The polycythemia persisted approximately six weeks (Figs. 1 and 2). There was no significant difference in the reticulocyte percentages of the two groups. The detailed results of all the various determinations will be presented in a forthcoming paper.

Comment

It is believed that this procedure of red cell transfusion in normal men reproduces to a large extent the physiological pattern of acclimatization to altitude. There were both subjective and objective indications that the transfused group tolerated hypoxia significantly better than the control group. The fact that the red cells persisted six weeks is of considerable interest. This period is longer than might have been anticipated from homeostatic considerations and yet shorter than what is said to be the life of the human red cell following transfusion,[7,8] namely, about three months. Thus, either the transfused cells were destroyed at a slightly increased rate or the polycythemia resulted in a reduction of the stimulus to normal erythropoiesis. Neither the urinary pigment excretion nor the reticulocyte counts of the transfused group, however, differed significantly from that of the control group.

The use of "arterialized" venous blood[6] for arterial

[7] W. Ashby, *Jour. Exp. Med.*, 29: 267, 1919.
[8] A. S. Wiener and G. Schaefer, *Med. Clin. N. Amer.*, 24: 705, 1940.

blood chemistry has been validated in this laboratory by comparison with blood obtained by arterial puncture in both normal and polycythemic (induced by red cell transfusion) men at various degrees of oxygen saturation.

CONCLUSION

The direct transfusion of erythrocytes into normal young men appears to be a safe procedure and when the volumes transfused are sufficiently great, the resultant polycythemia appears to afford increased tolerance to hypoxia. The polycythemia persists approximately six weeks.

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CYTOPLASMIC DISEASES AND CANCER

RECENT articles by Dixon,[1] Potter[2] and others prompt us to review various data obtained in certain fields and to interpret these in the light of a theory we have proposed that links three groups of diseases: namely, virus diseases, variegational diseases and cancer. The theory is based on the similarity of plants and animals at cellular and subcellular levels. Realization of this similarity has repeatedly shown the way to new approaches in research. We only have to mention a few cases: (a) the laws of heredity, proven for plants and applied to animals; (b) studies on enzyme and respiration processes in yeast and organs of higher plants, often elucidating similar processes in animals; (c) studies on plant viruses, indicating the way for isolation and purification of animal viruses; (d) studies on lower plant and animal forms, demonstrating the similarity of these forms on a cellular level.

That the ultimate agent of cancer may reside in the cytoplasm was suggested by Warren Lewis,[3] among others, in 1936. However, he did not specify what component of the cytoplasm might be involved. In recent years there has been an increasing tendency[2,3,4] to consider many cancers as cytoplasmic diseases and to regard the nuclear abnormalities associated with them of a secondary nature. Without doubt certain diseases of the tumor type are induced by viruses: *e.g.*, the Shope papilloma and Rous sarcoma. Oberling[4] has suggested that all cancers may ultimately be shown to be virus diseases. However, in the great majority of cases it has not been possible to demonstrate a causal virus. Moreover, the induction of cancer by specific carcinogenic agents such as methylcholanthrene, x-rays, etc., can be explained on the basis of the pure virus theory only when a series of rather involved assumptions are made. Granting that some cancers may be cytoplasmic diseases, that viruses are for the most part typically associated with the cytoplasm and that at least some cancers are virus-induced, what evidence do we have for a theory which reconciles both the virus and the so-called non-virus theories of cancers?

There have been numerous theoretical discussions on this subject, but in practically all instances definite experimental or observational evidence has been lacking. After Bensley and Hoerr[5] in 1934 separated mitochondria from liver tissue, Claude[6] in 1940 isolated from tumor tissue macromolecular complexes containing ribose nucleoprotein. He subsequently suggested that these fractions might be identical with mitochondria and that they might have an etiologic significance. However, considering the rate of cell division of neoplastic tissues, the mere presence of mitochondria in such tissues is not of itself significant, because mitochondria are always abundant in dividing tissue. Claude could not show that the fraction differed qualitatively from a similar fraction obtained from normal tissues nor did he point to any analogous case in which plant or animal mitochondria function as pathogenic entities.

As a result of studies on the interrelations of plastid chromoprotein, tobacco mosaic protein and cell metabolism, Woods and duBuy suggested in 1941[7] that a fundamental relationship might exist between mitochondria (or plastids, which are specialized mitochondria *sensu* Guilliermond) and virus proteins. Later, in 1943,[8,9] they were able to show that plant variegations are diseases often of virus-like nature, which are caused by abnormal cytoplasmic particulates of hereditary character: the plastids or mitochondria. That plastids can be modified by a nuclear factor, and that this modification is transmitted thereafter by cytoplasmic heredity, was shown in maize by Rhoades in 1943.[10] Other cases of plastid inheritance were reported by Anderson, Demerec, Imai, Renner and others.[11] Woods and duBuy were able to establish a "spectrum of variegation" ranging from

[1] T. F. Dixon, *Nature*, 155: 596, 1945.
[2] Van R. Potter, SCIENCE, 101: 609, 1945.
[3] Warren H. Lewis, SCIENCE, 81: 545, 1935.
[4] Ch. Oberling, "The Riddle of Cancer," Yale University Press, 1944.
[5] R. R. Bensley and N. L. Hoerr, *Anat. Rec.*, 60: 251, 1934.
[6] A. Claude, SCIENCE, 91: 77, 1940.
[7] M. W. Woods and H. G. duBuy, *Phytopath.*, 31: 978, 1941; *id.*, 32: 288, 1942.
[8] M. W. Woods and H. G. duBuy, *Phytopath.*, 33: 637, 1943.
[9] H. G. duBuy and M. W. Woods, *Phytopath.*, 33: 766, 1943.
[10] M. M. Rhoades, *Proc. Nat. Acad. Sci.*, 29: 327, 1943.
[11] E. G. Anderson, *Bot. Gaz.*, 76: 411, 1923; M. Demerec, *Bot. Gaz.*, 84: 139, 1927; Y. Imai, *Genetics*, 13: 544, 1928; O. Renner, *Flora*, 30: 218, 1936.

the normal plastids through mutated mitochondria to typical viruses. These mutated mitochondria, of course, persist only when they are to a certain extent compatible with the genic constitution of the cell. Since Guilliermond and others[12] have shown that plastids are specialized mitochondria, the variegational plant diseases can be considered as mitochondrial diseases.

The authors further described numerous instances in which the presence of abnormal (mutated) plastids causes profound changes in cell metabolism; *e.g.*, disturbances in oxidizing enzyme systems, cell differentiation and growth, functions of the normal plastidome, etc. Thus factual evidence has been supplied for the validity of the suggestion made by A. F. Woods over forty years ago[13] that certain "non-infectious" variegations and certain viroses of the mosaic type are fundamentally the same. In the most extreme cases of cell disturbance these changes were so great that the cells remained more or less isodiametric or undifferentiated in form, thus paralleling some of the conditions found in cancer. More recently we have been able to demonstrate the influence of temperature on the relative dominance of either the normal or the pathogenic chondriosomal systems when both exist in the same cell.[14] From these observations it has been possible to offer by analogy definite suggestions as to what may be the underlying phenomena governing the latent period, initiation, development or regression of cancers, namely changes in chondriosomal equilibria.

We could demonstrate the presence of a ribose nucleoprotein in virus-free plastids, thus confirming the earlier report by Menke[15] of the presence of this type of protein in the plastid. Attention was called to the apparent relation between the ribose nucleoprotein components of the normal and the variegation-inducing plastids or mitochondria, and the ribose nucleoprotein constituting the pathogenic viruses. Considering the self-perpetuating nature of the abnormalities it was suggested that the mutational change in the plastids probably occurred in the ribose nucleoprotein component of the disease-causing entities, the chondriogene.

Since it has long been recognized, though sometimes forgotten, that plant and animal mitochondria are fundamentally alike, animal mitochondrial diseases might be expected to occur. Although the exact functions of animal mitochondria are not fully understood, there is increasing evidence that the mitochondria play an important role in controlling cell metabolism.[16] Hence, mitochondrial diseases in animals should be characterized by a disturbed cell metabolism in which the disturbing agent is self-perpetuating in the cytoplasm. Mitochondria, changed by a process of "retrograde" evolution, could be considered as the underlying cause not only of the plastid-controlled variegational diseases and ultimately of the viroses, but also, through a similar course of evolution, as the underlying causes of many cancers. As far as we are aware, the first experimental data to be presented pointing to such a fundamental relationship among these three types of diseases are given in our earlier papers.

On the basis of the data presented in these papers we can consider the viroses as infectious diseases caused by entities evolved from one-time normal cell components, namely, the ribose nucleoprotein components of the plastids or mitochondria. In the case of the variegational diseases, we deal with recently produced pathogenic cytoplasmic particulates, the variegation-inducing plastids or chondriosomes. Is it not highly plausible that similar conditions exist in animals? Thus we might expect to find cancer-inducing viruses at one end of a "cancer spectrum" and at the other localized cancer-inducing mitochondria, which should be demonstrable serologically and probably microchemically, corresponding to the spectrum of variegation-inducing plastids (mitochondria) of plants. In this connection it should be stressed that this theory does not hold that all agents now classed as viruses in animals are necessarily of mitochondrial origin. Agents such as those causing psittacosis, vaccinia, etc., may be more closely allied to known organisms such as the agents of pleuropneumonia, agalactia, etc., than to the true viruses. The detailed reasons for the acceptance of a biphyletic origin of the macroviruses on the one hand and of the true viruses on the other can not be elaborated here. The theory does not require that all the viruses which attack a given species, man for example, have necessarily arisen from chondriosomal proteins of the same species. In fact, the wide host range of some animal viruses suggests that chondriosomal nucleoproteins of many phyla may be involved.

Since our original publication of the foregoing concept relating viruses, pathogenic mitochondria (plastids) and hypothetical cancer-inducing mitochondria, Haddow[17] and Darlington[18] in England, and more recently Potter[2] in America, have broached somewhat similar concepts in theoretical reviews. In

[12] A. Guilliermond, G. Mangenot et L. Plantefol, *Traité de cytologie végétale*, Le Francois, Paris, 1933; A. Guilliermond, "The Cytoplasm of the Plant Cell," Chron. Bot. Co., Waltham, Mass., 1941.

[13] A. F. Woods, *Centralbl. f. Bakt. u. Par. Krankh.*, 5(II): 745, 1899.

[14] M. W. Woods and H. G. duBuy, *Phytopath.*, in press.

[15] W. Menke, *Ztschr. f. Physiol. Chem.*, 257: 43, 1938.

[16] A. Claude, *A.A.A.S. Research Conference on Cancer*, 4: 232, 1945.

[17] A. Haddow, *Nature*, 154: 194, 1944.

[18] C. D. Darlington, *Nature*, 154: 164, 1944; *id.*, 154: 489, 1944.

interpreting the paper of Darlington in particular, it is important to recognize that (a) there is an extensive experimental basis for the acceptance of a nuclear hereditary system; (b) there is increasing evidence for the existence of an extra-nuclear, mitochondrial hereditary system; (c) there is *no* evidence for a diffuse cytoplasmic hereditary system (Sonneborn's data[19] quoted by Darlington as evidence can be differently interpreted on the basis of experiments supplied by Marshak and Walker[20]); also, mitochondrial exchange has not been excluded in Sonneborn's experiments. Darlington does not even mention mitochondria, but only plastids of green plants); and (d) the development of simple non-hereditary cytoplasmic proteins into hereditary systems is entirely without experimental proof. A casual student might find illuminating and thought-provoking the postulate that a non-hereditary protein gradually develops into an hereditary protein, and this, via a particulate hereditary system, into a nuclear hereditary system. Such a view implies that any change in any part of the cell might be the cause of cancer and is, therefore, of little help to the person who has to make a choice among the many experimental approaches to the cancer problem.

It is possible that hereditary particulates of the cytoplasm, other than the mitochondria or plastids, may exist and may develop into pathogenic agents, but the important issue is that we do not have adequate evidence for their existence. On the other hand, we do have proof of the occurrence in nature of known cytoplasmic particulates that can become pathogenic and that can be connected with viruses by gradual steps in a "spectrum of variegation."

In the plastid-induced variegations of plants we have access to concrete facts which may well be applied to the solution of the cancer problem. We have at least been able to set up a theory which reconciles both the virus and so-called non-virus theories of cancer. In addition, it offers an explanation for such phenomena as latency, fluctuations in activity of tumor cells, etc. Also, the precise cellular structures which are changed at the induction of a cancerous condition are indicated. The data obtained from studies on cytoplasmic particulates of plants can offer leads for studies in the much more difficult field of animal cytoplasmic diseases.[21] They will help the workers in the field of cancer to make a choice among the great number of scientific approaches possible in their complex field.

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[19] T. Sonneborn, *Proc. Nat. Acad. Sci.*, 29: 329, 1943; *id.*, 29: 338, 1943.

[20] A. Marshak and A. C. Walker, *Amer. Jour. Physiol.*, 143: 235, 1945.

[21] H. G. duBuy and M. W. Woods, *A.A.A.S. Research Conference on Cancer*, 4: 162, 1945.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ANTIBIOTIC FROM A BEE PATHOGEN

THE fact that honeybee larvae dead of American foulbrood (scales) almost invariably contain pure cultures of *Bacillus larvae* suggested that this organism might produce an antibiotic. When such scales were placed on the surface of freshly seeded nutrient agar plates of a soil suspension, and of market milk, definite inhibition zones were noted. Since antibiosis against a wide bacterial flora was thus shown, qualitative studies were made employing cultures of Gram-positive, Gram-negative and acid-fast bacteria.

Inhibition zones were produced around scales placed on plates seeded with the following cultures: *Staphylococcus aureus, Staphylococcus albus, Streptococcus agalactiae, Escherichia coli, Aerobacter aerogenes, Brucella abortus, Brucella melitensis, Bacillus subtilis, Bacillus alvei, Mycobacterium tuberculosis* var. *hominis, Mycobacterium tuberculosis* var. *bovis.* No inhibition occurred with *Mycobacterium avium* or an unidentified acid-fast bacterium from a skin lesion. Secondary or "clearing" zones appeared progressively around the original inhibition zones with *B. subtilis* and *E. coli,* but not with *Staph. aureus.* Such zones produced no growth on subculture, even though, with *B. subtilis,* numerous spores were present.

The size of the inhibition zone around scales on agar plates seems to be a function of the diffusion properties of the antibiotic rather than a measure of its concentration or activity against a particular organism. Thus, approximately equal zones are produced around *E. coli* and *B. subtilis;* yet an aqueous scale extract which inhibited *B. subtilis* in nutrient broth at a dilution of 1:20,000 inhibited *Staph. aureus* at only 1:2,000. The cup assay method has not proved feasible.

What appears to be the identical antibiotic is produced in culture by *B. larvae,* but only, as has been shown for certain enzymes,[1] when sporulation occurs. Sporulation has not been attained in broth culture.

A peculiarity was noted when *B. larvae* was grown on serum-glucose-potato extract agar in the presence

[1] E. C. Holst and A. P. Sturtevant, *Jour. Bact.*, 40: 723–731, 1940.

of the human or bovine strains of the tubercle organism. On this medium *B. larvae* cultures grow well, but fail to sporulate. When the tubercle organisms are present, however, sporulation occurs. Since the human and bovine strains studied show a different inhibition response to the presence of *B. larvae* and since the avian strain is not inhibited, a cultural method of differentiating such strains might be possible.

The antibiotic is soluble in water, but not in the common organic solvents or alcohols. It is adsorbed on activated charcoal or infusorial earth, but no eluent has been found. The material does not pass through either a Cellophane or a parchment membrane. It possesses moderate heat stability and can be sterilized by pasteurization without appreciable loss of potency. Active preparations have been obtained from scales held for over four years in the laboratory. Antibiotic activity is greatly inhibited by the presence of glucose, but not by sucrose, glycerol, xylose or cysteine.

A certain amount of toxicity was demonstrated when a scale extract was injected intraperitoneally into mice, but no toxicity was evident upon oral adminstration. Experiments to determine possible therapeutic use are in progress.

The writer wishes to acknowledge the assistance of C. K. Mingle and J. O. Heishmann, of the Animal Disease Station of the Agricultural Research Center, in preparing certain cultures, and especially the help of A. Frank in preparing the *Mycobacterium* cultures.

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THE CONTINUOUS CULTIVATION OF MICRO-ORGANISMS

IT was in the belief that micro-organisms could be so handled that the substrate could be continuously collected, spent organisms removed and fresh substrate added that the following two experiments were performed.

Experiment 1. The cultivation of Penicillium notatum. All glassware was chemically clean and sterile before the start of the run and all manipulations were done in a manner to maintain sterility or rather to prevent the entrance of organisms foreign to the desired ones.

The *Penicillium notatum* used was an experimental surface-growing strain that under normal handling had been producing 50 units per cubic milliliter[1] of substrate. The substrate was the standard corn steep composition and four days was chosen as the incubation period.

Daily cultivations from the removed matt showed that during the course of the run no morphological change occurred to the organism and no change in its penicillin production could be detected. Daily estimations of the penicillin level of the outflow from the apparatus showed no change.

The diagram of the apparatus is self-explanatory. Sizes of glassware were dictated by availability and may not have been optimum. The prime requisite of the set-up is the regulation of the flow and removal of the matt at such a rate that self-inoculation occurs with the minimum lag period and the removal of adult organisms before they can mutate.

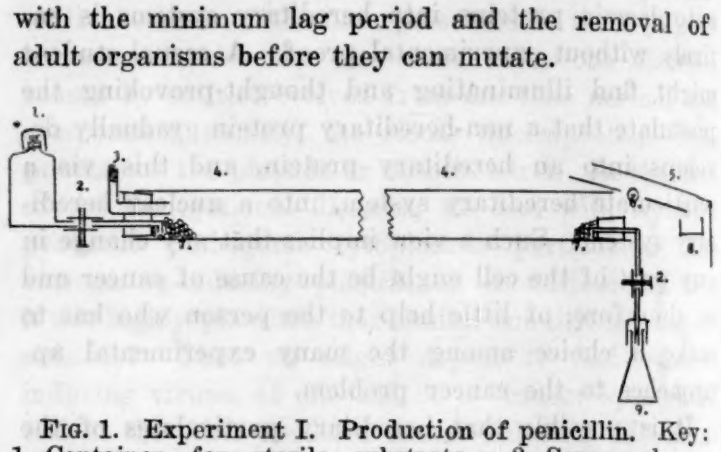

FIG. 1. Experiment I. Production of penicillin. Key: 1. Container for sterile substrate. 2. Screw clamps to regulate inflow and outflow, in this case 20 ml per hour. 3. Aeration tube (cotton plugged). 4. Fermentation tube in this case 4 cm × 200 cm and containing 200 cc of fermenting substrate. 5. Glass baffles to protect open end of tube. 6. Emery covered roller to remove matt. 7. Glass beads to fill lower portion of fermentation tube so that a thin film of fluid floats the matt. 8. Jar to hold removed matt. 9. Shielded container to hold penicillin containing outflow.

Experiment II. Cultivation of Yeast. To determine the possibility of utilizing the principles involved in the Penicillium experiment with other organisms the following experiment was set up.

A commercial strain of brewers' yeast was used. The details of the apparatus had to be varied due to the difference in characteristics of the organism. The wire screens indicated in the diagram serving as baffles worked with relative satisfaction, the outflow being only slightly turbid. The yeast cells in the collecting columns compacted to remove most of the fluid and yielded a pasty mass of cells.

The alcohol estimation of the outflow was based on the specific gravity and is quite inaccurate, the per cent. on this basis was indicated as about 4 and did not vary more than a very small amount from day to day. Daily culture of the yeast at the removal point did not show any change in characteristics.

The diagram (Fig. 2) is self-explanatory. As with the first experiment sizes were determined by availability and are probably not optimum.

Aeration of the reaction chamber in both experi-

[1] Recently strains of Penicillium have been isolated having much greater yields than the strain used. This, however, does not have any bearing on the experiment itself.

ments was adequate, although a forced draft could have been used if desired.

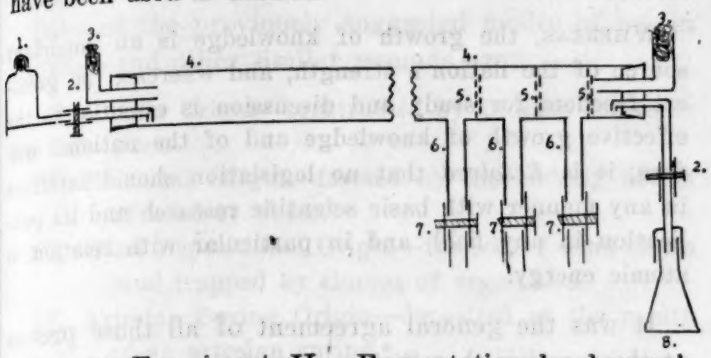

FIG. 2. Experiment II. Fermentation by brewer's yeast. Key: 1. Container for sterile substrate. 2. Screw clamps to regulate inflow and outflow in this case 50 ml per hour. 3. Aeration tubes cotton plugged. 4. Fermentation tube in this case 4 cm × 200 cm and containing 300 ml of substrate. 5. Wire screen baffles to help deposit of yeast cells in side arms. 6. Side arms for partially compacting and removing yeast cells. These side arms were 2 cm by 50 cm. 7. Screw clamps for use in removing semi compacted yeast mass. 8. Container for alcohol containing fluid.

These two experiments are presented with the idea that a useful method has been devised for the massive cultivation of micro-organisms without resort to very large containers with the attendant loss of time for discharge, cleaning and recharging. It is also believed that the technique could be applied to the cultivation of any micro-organism if the proper modifications in the basic apparatus were devised.

It is believed that the method would prevent a large loss of substrate by preventing the formation of mutants and by the possibility of stopping the reaction at any point if contamination should occur with only the loss of the preceding material.

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SOCIETIES AND MEETINGS

THE AMERICAN PHILOSOPHICAL SOCIETY

THE American Philosophical Society and the National Academy of Sciences held a joint meeting in Philadelphia on Friday and Saturday, November 16 and 17, 1945. The open sessions were devoted to a symposium on "Atomic Energy and its Implications." About four hundred members of the two societies and specially invited guests were present. Because of this large number and the fact that the meetings were open the sessions on Friday were held in the auditorium of the University Museum of the University of Pennsylvania, and on Saturday the open session was held in the Old Custom House, Chestnut Street below Fifth, now occupied by the Carl Schurz Foundation. At each of the open sessions there were approximately six hundred persons present.

The following papers were read at the morning and afternoon sessions on Friday:

Henry DeWolf Smyth, Princeton University, "The Scientific Background of the Atomic Bomb."

J. Robert Oppenheimer, California Institute of Technology, "Atomic Weapons."

Robert S. Stone, M.D., University of California, "The Health Protection Activities on the Plutonium Project."

Joseph H. Willits, The Rockefeller Foundation, "The Process of Social Adjustment to Atomic Energy."

Jacob Viner, University of Chicago, "Implications of Atomic Bomb for International Relations."

Irving Langmuir, General Electric Company, Schenectady, "World Control of Atomic Energy."

James T. Shotwell, Carnegie Endowment for International Peace, "The Control of Atomic Energy under the Charter."

Awards made by the National Academy of Sciences at the dinner on Friday evening at the Benjamin Franklin Hotel were announced in SCIENCE for November 30.

Preceding the Friday evening lecture by Arthur Holly Compton on "Atomic Energy as a Human Asset," which was given in the Auditorium of the Edison Building of the Philadelphia Electric Company, Dr. Conklin presented the Benjamin Franklin Medal of the American Philosophical Society on behalf of the society. After reviewing the history of this medal he turned to Dr. Compton and said "To you, Arthur Holly Compton, preeminent in science, distinguished successor of Franklin in exploring the fire from the sky in the form of cosmic rays, philosopher and statesman in education, ethics and international relations the American Philosophical Society awards this Benjamin Franklin Medal."

The following papers were read at the open session on Saturday:

Harold C. Urey, University of Chicago, "Methods and Objectives of Isotope Separation."

Enrico Fermi, University of Chicago, "The Development of the First Chain Reacting Pile."

Eugene P. Wigner, Princeton University, "Resonance Reactions."

John Wheeler, Princeton University, "Problems and Prospects in Elementary Particle Research."

All the papers read at this meeting will be published in No. 1 of Volume 90 of the Proceedings of the American Philosophical Society.

President Frank B. Jewett, of the National Academy of Sciences, telegraphed President Truman that the council of the academy at its meeting on November 15 in Philadelphia in connection with the joint meeting of the academy and the American Philosophical Society on "Atomic Energy and its Implications" expressed unanimous approval of the published text of the Declaration on Atomic Energy issued that day (November 15) jointly by President Truman and Prime Ministers Attlee of Great Britain and Mackenzie King of Canada.

The members of the American Philosophical Society in executive session on November 17, at the time of the joint meeting of the society and the National Academy of Sciences, adopted the following resolution to be presented to the President of the United States:

WHEREAS, the growth of knowledge is an important source of the nation's strength, and whereas, the greatest freedom for study and discussion is essential to the effective growth of knowledge and of the national welfare, it is *Resolved* that no legislation should interfere in any manner with basic scientific research and its publication in any field, and in particular with relation to atomic energy.

It was the general agreement of all those present at the meeting that it was one of the most important and successful meetings ever held by either society.

L. P. EISENHART
HALL OF THE AMERICAN
PHILOSOPHICAL SOCIETY

DISCUSSION

THE SMALL MOUNDS OF THE GULF COASTAL PLAIN

IN various parts of the United States and in other parts of the world, areas of abundant small mounds have been frequently discovered and reported.[1,2,3] Of these, the mounds of the Gulf Coastal Plain are among the best known. During 1942 and 1943, the writer made almost daily airplane flights over various parts of the United States, but especially in the coastal areas of Texas and Louisiana, which afforded an opportunity to observe the excellently developed small mounds of the Gulf Coast. A further study was made on the ground where aerial observation showed these mounds to be well developed. Inasmuch as the writer has arrived at conclusions concerning their origin which differ from any theory that to his knowledge has been previously proposed, a discussion of these mounds is briefly presented here.

The mounds are present by the hundreds of thousands in a broad belt along that part of the Gulf Coastal Plain extending from near the Corpus Christi region of Texas eastward to the vicinity of Lafayette, Louisiana, where the mound-containing sediments are abruptly truncated by Mississippi alluvium. They are best developed and are nearly everywhere present in southeast Texas and southwest Louisiana on level or almost-level ground, where they form the so-called "pimple prairies." They are most commonly present and they are of most perfect form immediately to the landward of coastal lagoons, whereas inland the mounds are generally more scattered and less well-preserved. Mounds, of the type referred to here, are completely absent from the barrier beaches and related beach deposits and, also, are absent from the extensive area covered by wind-blown sand in the region between Corpus Christi and the Rio Grande River. In fact, the mounds are wholly confined to areas which appear to be brackish-swamp-deposited facies of the two extensive Quaternary formations, the Beaumont and the Lissie.

The mounds are symmetrical in form and rather uniform in size and shape. They are circular in ground plan and in vertical section they have the shape of a low flattened dome. Although they may vary in diameter from ten to one hundred feet, and in height from one to five feet, they average about thirty to fifty feet across and about two or three feet in height. Where the hillocks are well developed, they are scattered at intervals of about one hundred feet and occupy from ten to twenty-five per cent. of the land.

The mounds consist of dark gray loamy sand which at a depth ranging from two to four feet grades into a loamy clay similar to that of the inter-mound areas. No gravel is present either in the mounds or in the areas between them. No fossils or artifacts are found in these hillocks; however, inasmuch as layers of calcareous concretion are found in the subsoil, it is likely that fossils have been leached from the mounds. They are nearly always topped with a thick growth of tall dark-green weeds which makes them easy to see from the air. The mounds have no elongate axes and they do not have any other apparent orientation but rather are scattered at random. However, collectively, the mounds tend to be distributed in irregular belts parallel to the coast line. Commonly associated with the mounds are circular patches of sand which are commonly referred to locally as "sinks" or "slick spots." No vegetation grows upon these sandy

[1] A. C. Veatch, U. S. Geological Survey Prof. Paper 46, pp. 55–59, 1906.
[2] W. A. Dalquest and J. G. Scheffer, *Jour. Geol.*, 50: 1, 68–84, 1942.
[3] J. C. Branner, SCIENCE, n.s., 21, 514–516, 1905.

spots and, consequently, they appear as prominent white scars from the air.

Some of the previously suggested modes of origin for these and other similar mounds are:

I. Human Origin—constructed by Indians for tepee sites.[1]

II. Erosional Origin—formed by the carving action of wind or water.[1]

III. Wind Depositional Origin—formed of wind-blown sand trapped by clumps of vegetation.[1]

IV. Artesian Spring Origin—deposited at the mouth of an artesian spring.[4]

V. Animal Origin—formed by burrowing animals,[2] such as gophers, prairie dogs or ground squirrels, or by insects such as hill-building ants.[1]

Of these suggested theories, the last one is probably the most generally accepted and, consequently, it is noteworthy that neither present-day nor fossil burrows were found by the writer and that ant hills were not frequently encountered. Moreover, one would expect the distribution of hillocks formed by animals to be independent of geological formations. The fact that they are definitely confined to areas of Quaternary brackish water sediments indicates that such deposits are directly associated with the origin of the mounds. Furthermore, although the writer has flown over and traveled over many parts of the Great Plain where one would expect mounds formed by burrowing animals to be best developed, he has not observed any mounds even remotely resembling those of the Gulf Coastal Plain.

It is the writer's belief that the mounds are water-deposited features originating as sandy islets along the margin of marsh-grass-lined lagoonal swamps. Aerial observations of many inaccessible areas, such as along the shore of Sabine Lake, Calcasieu Lake and on the landward side of the lagoon in the vicinity of Galveston, shows these islets along the shore in various stages of formation and grading into mounds preserved on land. During the process of filling-in of the lagoons by sedimentation the marsh grass of the shore line encroaches, not as an even stand of marsh grass, but rather by advancing into the lagoon in circular clumps as spots offshore become shallow enough to permit the grass to gain a foothold. After a few plants have gained such a foothold, they tend to trap sand and, in this manner, a submerged or slightly emerged islet surmounted by a thick clump of grass is constructed. When preserved by shoreline emergence, these small islets eventually form the small mounds that dot the coastal plain. In some areas islet-lined lagoons grade into level swamp land which farther inland becomes a so-called pimple prairie. In such cases, it is quite probable that the islets are preserved as sand lenses when the inter-mound areas become completely filled with silty clay. However, when the ground dries the mounds may again appear in relief as a result of the greater compaction of the clay between the mounds, compared to that of the sand composing them.

[4] T. L. Bailey, *Univ. of Texas Bull.*, No. 2333, 22–30, September 1, 1923.

ROBERT S. DIETZ

AN UNUSUAL ACTION OF AMPHETAMINE

WHILE screening compounds for amphetamine-like actions I observed the following interesting phenomenon: When fireflies were moistened on the abdomen with 0.5 per cent. to 2 per cent. amphetamine sulfate solution the normally intermittent glow became continuous for hours at a time. The more concentrated amphetamine solutions appeared to result in longer action.

Mr. G. R. Fessenden of this laboratory suggested the morning-glory beetle Metriona bicolor as a substitute for the firefly. This insect periodically assumes a gold color, which it loses when disturbed. Application of amphetamine solution to the beetles resulted in their developing a gold color which persisted for days and was not discharged by disturbing. We also applied amphetamine to ctenophor jelly-fish without effect on their luminescent behavior.

We are now attempting to ascertain whether this action is specific for amphetamine and whether it is on a luminescent enzyme system or on a muscular shutter system. The medico-legal uses of this test are also being explored.

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AN APPEAL FOR AID TO THE PHILIPPINE BUREAU OF FISHERIES

I HAVE been asked to aid in rebuilding the working library of the Philippine Bureau of Fisheries. The Japanese wantonly destroyed the great scientific library of the Bureau of Science and all scientific collections. In addition, the members of the staff of the Bureau of Fisheries lost all their possessions, including their professional libraries.

The resumption of work at the Bureau of Fisheries is under very great handicaps, not the least of which is the entire absence of all printed matter on fish and fisheries.

I therefore ask scientific men all over the country to contribute anything they can spare on fish, fisheries, fish culture and the like. Send material to me at the address given below. I shall undertake to see that it gets to the Bureau of Fisheries at Manila.

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SCIENTIFIC BOOKS

WILD NATURE

Our Heritage of Wild Nature. By A. G. TANSLEY, F.R.S., 74 pp. 26 photographs. Cambridge: at the University Press; New York: The Macmillan Company. 1945. $2.50.

PLANS for rebuilding the war-torn, crowded island of Britain at first gave little consideration to the conservation of flora and fauna in natural areas. Cities, industry, commercial forestry, agriculture—all were making desperate, overwhelming demands.

This book pleads for organized conservation of wild life—before it is too late.

Some "planners" envision a Britain where every foot of ground will be blue-printed into towns and cities, tilled areas, forest plantations and intensively used playgrounds and resorts. This would mean the end of a rural landscape which, in its combination of wild forests, heaths and moorlands together with tillage and pasture, is distinctive and beautiful. Preservation of the wild and half-wild areas is necessary not only for their own sake, but as habitats for wild life. Conservation of many animal species, including the two native deer, the mice and voles, the rabbit and several carnivores, require lands on which agriculture or other interests are subordinate.

The types of vegetation and scenery of Britain and the alterations that have occurred in historic times are discussed briefly. Some biologically important types, such as oakwoods and alderwoods, are economically unprofitable. They, and their faunas, will therefore disappear unless the public acts. The seacoast, a particularly interesting national asset, is being preempted for private use. The early establishment of national reserves is imperative.

Professor Tansley traces the history of the nature reserve movement in Britain. A considerable number of protected areas exist, but there has been little coordination of effort. A national program is required. The Nature Reserves Investigation Committee in 1943 recommended the establishment of a series of small National Nature Reserves. These are planned chiefly for scientific purposes to preserve both flora and fauna.

For more than a decade Britain has been considering the need for National Parks, and a number of specific areas are now being examined by the Ministry for Town and Country Planning. These would be much more extensive than the proposed Nature Reserves, and would be primarily for public enjoyment. In regions where wild land is limited, the parks would be known as Scheduled Areas. In them present ownership or usage would not be changed. "The only restriction would be the prohibition of development destructive of the present character of the countryside." To preserve certain wild conditions, Nature Reserves might be established within National Parks and Scheduled Areas.

A Wild Life Service is recommended, to study the fauna and flora of Britain and to work with land management agencies to conserve it. The author recognizes the close affinity of such a service to the bureau which will operate the National Parks and especially the Nature Reserves. However, he believes it would be "difficult or even impracticable to burden" scientific investigators with administration of lands. Perhaps because of the troubled history of government control of predators in the United States, the British Wild Life Service would be specifically required to work closely with the humane societies if it became necessary to plan the destruction of large numbers of injurious mammals or birds.

The author recognizes the impossibility of establishing in populous Britain a series of extensive wild areas similar to the great national parks of the United States or Canada. His program for prohibiting further economic developments in specified areas and for maintaining modified habitats for interesting plants and animals makes the best of realities in a land where the primeval wilderness vanished centuries ago. Some of the policies suggested in this book might be applicable to our own eastern and middle-western country, where the purist in nature conservation laments that all is lost because extensive wilderness areas no longer are available.

Professor Tansley summarizes his book by recommending the establishment of a National Wild Life Service, National Nature Reserves and National Parks; enlarging the prerogatives of the Forestry Commission; and teaching conservation in the schools. He has condensed his excellent plea for organized nature conservation into 67 pages of text illustrated by 26 fine photographs.

VICTOR H. CAHALANE

PLANT SCIENCE IN LATIN AMERICA

Plants and Plant Science in Latin America. Edited by FRANS VERDOORN. xl + 384 double column pp. 83 plates + text illus. Waltham, Mass.: Chronica Botanica Co.; New York City: G. E. Stechert and Co. 1945. $6.00.

IF one is interested in the plant life of Latin America from almost any angle, even an amateurish one, this volume is the one to buy. Speaking broadly, it is the most comprehensive book so far published on the green world to the south of us. Great pains have been taken to procure material from authoritative sources. Almost a hundred authors of many nationalities have written accounts of the vegetation and

plant resources, involving information on agriculture, forestry, plant diseases, plant distribution, ecology, climatology, geology, economic plants, soils, mycology, conservation, ethnobotany and paleobotany. Most, if not all, of these men either live there, or have lived there.

Special features are very artistic plates, in many cases reproduced from classical publications on botany.

Pennell writes an interesting historical sketch in which one becomes quite well acquainted with botanical exploration and investigation up to 1850. Fosberg treats of the economic plants with references and native names, classified as to general use, such as fibers, insecticides, etc. Smith and Johnston in their phytogeographic sketch do an admirable job of telling you how the land lies in regard to the vegetation types. Popenoe presents an all-over picture of the problems of tropical agriculture, including those of agricultural education.

There are selected lists of travel books of botanical interest; an extremely interesting selected reference list, technical as well as general, involving guides, books by Carleton Beals, science congress proceedings, Adamic's description of Popenoe's house in Antigua and a mine of other intriguing items.

Several chapters are devoted to such subjects as "Agricultural Scholarships and Interamerican Relations," "Some of the Principal Latin-American Plant Science Periodicals," "Cooperative Agricultural Research and Extension Stations in Latin America," "On the Location of Botanical Collections from Central and South America," "The Advantage of the Tropical Environment for Studies on the Species Problem" and "Plant Breeding, Genetics and Cytology in Latin America."

Every country from Mexico to Argentina is covered, and most of the West Indian Islands are included. There are also treatments of the Falklands, Galapagos and Juan Fernandez. Most of the articles are in English, but a number are written in Spanish, French and Portuguese.

The most thought-provoking article in the book is the introductory essay by the editor entitled "The Plant Scientist in the World's Turmoils"—an essay, including the footnotes, which most scientists would do well to read carefully and meditatively.

One of the special features is subject to criticism, even though the editor in a footnote takes the blame. I refer to Dr. Lanjouw's "The Location of Central and South American Botanical Collections." The explanation of the symbols used to designate the herbaria does not occur in this volume, which is unfortunate, but which can be partly rectified by publishing such a list in pamphlet form at a nominal cost.

A detailed table of contents takes the place of a subject index. There are indices of personal names, plates and text illustrations.

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ORGANIC CHEMISTRY

The Characterization of Organic Compounds. By SAMUEL M. MCELVAIN, professor of chemistry, University of Wisconsin. ix + 282 pp. $8\frac{1}{2} \times 5\frac{3}{4}$ in. New York: The Macmillan Company. 1945. $3.40.

THE first important publication in this field was Mulliken's "Identification of Pure Organic Compounds," the initial volume of which appeared in 1905, and the fourth in 1922. This work was received so favorably that the issue of certain of the volumes was quickly exhausted and they have since been practically unobtainable. The first edition of Kamm's "Qualitative Organic Analysis" was published in 1922; and Staudinger's "Anleitung zur organischen qualitativen Analyse" in 1923. Shriner and Fuson's "Systematic Identification of Organic Compounds; a Laboratory Manual" came on the market in 1935, and in 1941 there appeared the "Identification of Pure Organic Compounds. Tables of Data on Selected Compounds of Order I," by Huntress and Mulliken, which, in general purpose, plan and function, as well as in the basis of its primary classification, resembled its predecessor of similar title. In other respects, however, the two are quite different, so that this new compilation should not at all be regarded as a new or revised edition of the earlier "Mulliken," but as an original contribution. The author of the book under review has adopted in the main the analytical treatment first advocated by Kamm, rather than that of the Mulliken volumes.

Based upon the experience of twenty-two years' teaching at the University of Wisconsin, with senior undergraduate and first-year graduate students from a great variety of American colleges and universities, its general purpose is to develop a systematic and comprehensive procedure for the identification of organic compounds and, in so doing, to bring home to the student the practical applications of the fundamental principles of the science and the distinguishing characteristics of the various classes of organic compounds upon which is based the really wonderful systematic classification of the whole limitless domain of organic chemistry.

It also provides an unrivaled opportunity for stimulating his interest in the subject and for passing on to him some of that inspiration and enthusiasm without which the teacher becomes merely a *vox et praeterea nihil.*

The procedure, which is developed in detail, con-

sists of four main steps: (1) The determination of the physical properties and the establishment of the purity of the compound; (2) determination of the class (aldehydes, amines, acids, etc.) to which the compound belongs (by qualitative analysis, solubilities and class reactions); (3) location of the compound within a class or possibly homologous series of compounds; and (4) preparation of derivatives.

Most, if not all, of our leading universities now offer such training as a third semester course and, in the opinion of the reviewer, it should always be required for admission to original research in organic chemistry.

The text is lucid and concise, with numerous detailed experiments, illustrations, graphs, structural formulas and tables. The book is bound in dark green cloth, with gold lettering, and a red phenanthrene nucleus as a lead for the title. Type and presswork are excellent. It should be very helpful and is heartily recommended.

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PLASTICS

The New Plastics. By HERBERT R. SIMONDS, M. H. BIGELOW and JOSEPH V. SHERMAN. xii + 320 pp. New York: D. Van Nostrand Company, Inc. 1945. $4.50.

THE plastics industry has come a long way in the past five years—so far, in fact, that the authors of the book in question considered it fitting to prepare a semi-technical volume devoted almost exclusively to plastic materials, processes and uses which have been developed since 1940.

There is little question of the timeliness of their effort. It is of the utmost importance to the plastics industry that its new materials, their war uses fulfilled, should not be allowed to fall into disuse and that new mass-production techniques should not give way to costlier methods for want of quantity demand.

Almost all the regular books on plastics are forced, of necessity, to deal with such a variety of topics that only the mass-produced, established plastics and their processing methods can be discussed in any detail. Since most references to these books are made for the purpose of finding data on specific materials for more or less standard types of application, this is usually fairly satisfactory, but the lack of detailed data on new developments may lead to their being overlooked, even where they could give superior service. Of more significance, however, is the fact that lack of recent information may cause the producer of a new product to turn away from plastics because he can not find, among the standard materials, one which could suit his purpose.

The present book is by no means an encyclopedia of all that has been accomplished since 1940, but it is an excellent attempt to condense the more important information into one volume. After a brief review of the industry prior to 1940, the authors discuss, in turn, the most recent developments (plastics such as polyethylene, nylon and the silicones); certain established new materials, such as the melamine, allyl and vinyl resins; and improvements in such substances as vinyl elastic molding materials and polystyrene.

The new synthetic fibers, closely related to plastics, are then considered, with considerable emphasis on nylon, Aralac and Vinyon. Other chapters deal with such new and important adhesives as Reanite and Cycleweld cements; various new laminating materials such as glass-cloth laminates; such new applications of wood and paper as Impreg, Compreg and methylolurea-treated wood; and the various synthetic rubbers, which are not discussed in any detail.

Much has been heard in recent years about molding with electronic heating, and this and other new processes are discussed, with the inclusion of significant economic data. New forms and coatings are considered in the last technical chapter, and the book is concluded with an all-too-brief chapter on plastic trends.

To quote the jacket, "this book furnishes the most complete information on the important advances made during the last five years by the entire plastics industry," although it may not quite constitute a "comprehensive manual of practical information on *all* the new developments in plastics." The present reviewer has followed these developments with interest during the period covered by the book, however, and feels that this compact volume is a worth-while addition to the bookshelf of every individual who has anything to do with plastics, unless that person has available a complete and indexed file of the recent literature. The style of writing is factual and clear, yet not too technical for the interested layman to appreciate, at least in part.

B. H. WEIL
GULF RESEARCH & DEVELOPMENT COMPANY,
PITTSBURGH, PA.

BOOKS RECEIVED

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STEARN, E. WAGNER and ALLEN E. STEARN. *The Effect of Smallpox on the Destiny of the Amerindian.* Pp. 7 + 153. Bruce Humphries, Inc. $2.50. 1945.

LIDDELL, DONALD M., Editor-in-chief. *Handbook of Nonferrous Metallurgy.* Second edition. Illustrated. Pp. xi + 721. McGraw-Hill Book Company. $7.00. 1945.